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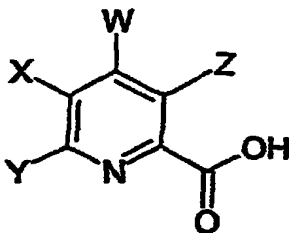
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(54) Title: 4-AMINOPICOLINATES AND THEIR USE AS HERBICIDES



(1)

(57) Abstract: 4-Aminopicolinic acids, having halogen, alkoxy, alkylthio, aryloxy, heteroaryloxy or trifluoromethyl substituents in the 3-, 5- and 6-positions, and their amine and acid derivatives of formula (I) wherein X represents H, halogen, C₁-C₆ alkoxy, C₁-C₆ alkylthio, aryloxy, nitro, or trifluoromethyl; Y represents halogen, C₁-C₆ alkoxy, C₁-C₆ alkylthio, aryloxy, heteroaryloxy or trifluoromethyl; Z represents halogen, C₁-C₆ alkoxy, C₁-C₆ alkylthio, aryloxy or nitro; and W represents -NO₂, -N₃, -NR₁R₂, -N=CR₃R₄ or -NHN=CR₃R₄ are potent herbicides demonstrating a broad spectrum of weed control.

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4-AMINOPICOLINATES AND THEIR USE AS HERBICIDES

This invention relates to certain novel 4-aminopicolinates and their derivatives and to the use
5 of these compounds as herbicides.

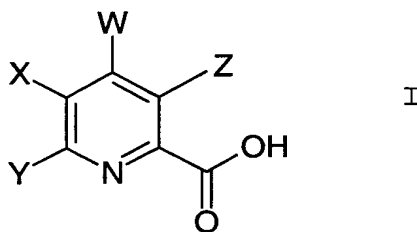
A number of picolinic acids and their pesticidal properties have been described in the art. For example, U.S. Patent 3,285,925 discloses 4-amino-3,5,6-trichloropicolinic acid derivatives and their
10 use as plant growth control agents and herbicides. U.S. Patent 3,325,272 discloses 4-amino-3,5-dichloropicolinic acid derivatives and their use for the control of plant growth. U.S. Patent 3,317,549 discloses 3,6-dichloropicolinic acid derivatives and
15 their use as plant growth control agents. U.S. Patent 3,334,108 discloses chlorinated dithiopicolinic acid derivatives and their use as parasitocides. U.S. Patent 3,234,229 discloses 4-amino-polychloro-2-trichloromethylpyridines and their use as herbicides.
20 In *Applied and Environmental Microbiology*, Vol. 59, No. 7, July 1993, pp. 2251-2256, 4-amino-3,6-dichloropicolinic acid is identified as a product of the anaerobic degradation of 4-amino-3,5,6-trichloropicolinic acid, the commercially available herbicide
25 picloram.

While picloram is recommended for the control of woody plants and broadleaf weeds in certain applications, its properties are not ideal. It would be highly desirable to discover related compounds that

are more potent, more selective or of broader spectrum in their herbicidal activity and/or that have improved toxicological or environmental properties.

It has now been found that certain 4-amino-
5 picolinic acids and their derivatives having selected substituents in the 3-, 5-, and 6-positions are potent herbicides with a broad spectrum of weed control and excellent crop selectivity. The compounds further possess excellent toxicological or environmental
10 profiles.

The invention includes compounds of Formula I:



15 wherein

X represents H, halogen, C₁-C₆ alkoxy, C₁-C₆ alkylthio, aryloxy, nitro or trifluoromethyl;

Y represents halogen, C₁-C₆ alkoxy, C₁-C₆ alkylthio, aryloxy, heteroaryloxy or trifluoromethyl;

20 Z represents halogen, C₁-C₆ alkoxy, C₁-C₆ alkylthio, aryloxy or nitro; and

W represents $-\text{NO}_2$, $-\text{N}_3$, $-\text{NR}_1\text{R}_2$, $-\text{N}=\text{CR}_3\text{R}_4$ or $-\text{NHN}=\text{CR}_3\text{R}_4$

where

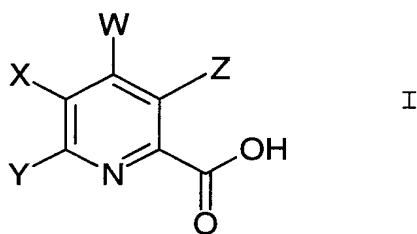
R_1 and R_2 independently represent H, $\text{C}_1\text{-C}_6$ alkyl, $\text{C}_3\text{-C}_6$ alkenyl, $\text{C}_3\text{-C}_6$ alkynyl, aryl, heteroaryl, hydroxy, $\text{C}_1\text{-C}_6$ alkoxy, amino, $\text{C}_1\text{-C}_6$ acyl, $\text{C}_1\text{-C}_6$ carboalkoxy, $\text{C}_1\text{-C}_6$ alkylcarbonyl, $\text{C}_1\text{-C}_6$ alkylsulfonyl, $\text{C}_1\text{-C}_6$ trialkylsilyl or $\text{C}_1\text{-C}_6$ dialkyl phosphonyl or R_1 and R_2 taken together with N represent a 5- or 6-membered saturated or unsaturated ring which may contain additional O, S or N heteroatoms; and

R_3 and R_4 independently represent H, $\text{C}_1\text{-C}_6$ alkyl, $\text{C}_3\text{-C}_6$ alkenyl, $\text{C}_3\text{-C}_6$ alkynyl, aryl or heteroaryl or R_3 and R_4 taken together with $=\text{C}$ represent a 5- or 6-membered saturated ring; and

agriculturally acceptable derivatives of the carboxylic acid, with the proviso that when X represents H or Cl, then Y and Z are not both Cl.

Compounds of Formula I wherein X represents H or F, wherein Y represents F, Cl, Br or aryloxy, wherein Z represents Cl and wherein R_1 and R_2 represent H are independently preferred.

The invention includes herbicidal compositions comprising a herbicidally effective amount of a 4-amino-picolinate of Formula I:



wherein

X represents H, halogen, C₁-C₆ alkoxy, C₁-C₆ alkylthio, aryloxy, nitro or trifluoromethyl;

5 Y represents halogen, C₁-C₆ alkoxy, C₁-C₆ alkylthio, aryloxy, heteroaryloxy or trifluoromethyl;

Z represents halogen, C₁-C₆ alkoxy, C₁-C₆ alkylthio, aryloxy or nitro; and

10 W represents -NO₂, -N₃, -NR₁R₂, -N=CR₃R₄ or -NHN=CR₃R₄

where

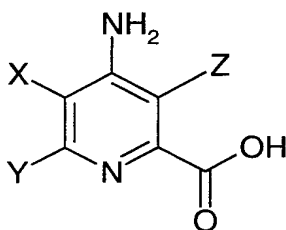
R₁ and R₂ independently represent H, C₁-C₆ alkyl, C₃-C₆ alkenyl, C₃-C₆ alkynyl, aryl, heteroaryl, hydroxy, C₁-C₆ alkoxy, amino, C₁-C₆ acyl, C₁-C₆ carboalkoxy, C₁-C₆ alkylcarbonyl, C₁-C₆ alkylsulfonyl, C₁-C₆ trialkylsilyl or C₁-C₆ dialkyl phosphonyl or R₁ and R₂ taken together with N represent a 5- or 6-membered saturated or unsaturated ring which may contain additional O, S or N heteroatoms; and

20 R₃ and R₄ independently represent H, C₁-C₆ alkyl, C₃-C₆ alkenyl, C₃-C₆ alkynyl, aryl or heteroaryl or R₃ and R₄ taken together with =C represent a 5- or 6-membered saturated ring; and

agriculturally acceptable derivatives of the carboxylic acid, with the proviso that when X represents Cl, then Y and Z are not both Cl

in admixture with an agriculturally acceptable
5 adjuvant or carrier. The invention also includes a method of use of the compounds and compositions of the present invention to kill or control undesirable vegetation by application of an herbicidal amount of the compound to the vegetation or to the locus of the
10 vegetation as well as to the soil prior to emergence of the vegetation. The use of the compounds to kill or control woody plants and broadleaf weeds in grass crops is a preferred utility and post-emergent application of the compounds to the undesirable
15 vegetation is a preferred method of application.

The herbicidal compounds of the present invention are derivatives of 4-aminopicolinic acids:



These compounds are characterized by possessing
20 halogen, C₁-C₆ alkoxy, C₁-C₆ alkylthio, aryloxy or nitro substituents in the 3-position with halogen being preferred and chlorine being most preferred; by possessing hydrogen, halogen, C₁-C₆ alkoxy, C₁-C₆ alkylthio, aryloxy, nitro or trifluoromethyl
25 substituents in the 5-position with hydrogen and fluorine being preferred; and by possessing halogen,

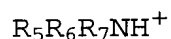
C₁-C₆ alkoxy, C₁-C₆ alkylthio, aryloxy, heteroaryloxy or trifluoromethyl substituents in the 6-position with fluorine, chlorine, bromine or aryloxy being preferred. Preferred aryloxy groups in the 6-position
5 are 3-substituted phenoxy groups, most preferably phenoxy groups substituted with halogen or C₁-C₄ alkyl groups in the 3-position.

The amino group at the 4-position can be unsubstituted or substituted with one or more C₁-C₆
10 alkyl, C₃-C₆ alkenyl, C₃-C₆ alkynyl, aryl, heteroaryl, hydroxy, C₁-C₆ alkoxy or amino substituents. The amino group can be further derivatized as an amide, a carbamate, a urea, a sulfonamide, a silylamine, a phosphoramidate, an imine or a hydrazone. Such
15 derivatives are capable of breaking down into the amine. An unsubstituted amino group or one substituted with one or more alkyl substituents is preferred.

The carboxylic acids of Formula I are believed to be the compounds that actually kill or
20 control undesirable vegetation and are typically preferred. Analogs of these compounds in which the acid or amine group of the picolinic acid is derivatized to form a related substituent that can be transformed within plants or the environment to a acid
25 group possess essentially the same herbicidal effect and are within the scope of the invention. Therefore, an "agriculturally acceptable derivative", when used to describe the carboxylic acid functionality at the 2-position, is defined as any salt, ester,
30 acylhydrazide, imidate, thioimidate, amidine, amide, orthoester, acylcyanide, acyl halide, thioester,

thionoester, dithiolester, nitrile or any other acid derivative well known in the art which (a) does not substantially affect the herbicidal activity of the active ingredient, i.e., the 4-aminopicolinic acid, and (b) is or can be hydrolyzed in plants or soil to the picolinic acid of Formula I that, depending upon the pH, is in the dissociated or the undissociated form. Likewise, an "agriculturally acceptable derivative", when used to describe the amine functionality at the 4-position, is defined as any salt, silylamine, phosphorylamine, phosphinimine, phosphoramidate, sulfonamide, sulfinimine, sulfoximine, aminal, hemiaminal, amide, thioamide, carbamate, thiocarbamate, amidine, urea, imine, nitro, nitroso, azide, or any other nitrogen containing derivative well known in the art which (a) does not substantially affect the herbicidal activity of the active ingredient, i.e., the 4-aminopicolinic acid, and (b) is or can be hydrolyzed in plants or soil to a free amine of Formula I. N-Oxides which are also capable of breaking into the parent pyridine of Formula I are also covered by the scope of this invention.

Suitable salts include those derived from alkali or alkaline earth metals and those derived from ammonia and amines. Preferred cations include sodium, potassium, magnesium, and aminium cations of the formula:



wherein R_5 , R_6 , and R_7 each, independently represents hydrogen or C_1 - C_{12} alkyl, C_3 - C_{12} alkenyl or C_3 - C_{12}

alkynyl, each of which is optionally substituted by one or more hydroxy, C₁-C₄ alkoxy, C₁-C₄ alkylthio or phenyl groups, provided that R₅, R₆, and R₇ are sterically compatible. Additionally, any two of R₅,
5 R₆, and R₇ together may represent an aliphatic difunctional moiety containing 1 to 12 carbon atoms and up to two oxygen or sulfur atoms. Salts of the compounds of Formula I can be prepared by treatment of compounds of Formula I with a metal hydroxide, such as
10 sodium hydroxide, or an amine, such as ammonia, trimethylamine, diethanolamine, 2-methylthiopropylamine, bisallylamine, 2-butoxyethylamine, morpholine, cyclododecylamine, or benzylamine. Amine salts are often preferred forms of the compounds of
15 Formula I because they are water-soluble and lend themselves to the preparation of desirable aqueous based herbicidal compositions.

Suitable esters include those derived from C₁-C₁₂ alkyl, C₃-C₁₂ alkenyl or C₃-C₁₂ alkynyl alcohols,
20 such as methanol, *iso*-propanol, butanol, 2-ethylhexanol, butoxyethanol, methoxypropanol, allyl alcohol, propargyl alcohol or cyclohexanol. Esters can be prepared by coupling of the picolinic acid with the alcohol using any number of suitable activating
25 agents such as those used for peptide couplings such as dicyclohexylcarbodiimide (DCC) or carbonyl diimidazole (CDI), by reacting the corresponding acid chloride of a picolinic acid of Formula I with an appropriate alcohol or by reacting the corresponding
30 picolinic acid of Formula I with an appropriate alcohol in the presence of an acid catalyst. Suitable amides include those derived from ammonia or from

C₁-C₁₂ alkyl, C₃-C₁₂ alkenyl or C₃-C₁₂ alkynyl mono- or di-substituted amines, such as but not limited to dimethylamine, diethanolamine, 2-methylthiopropylamine, bisallylamine, 2-butoxyethylamine, cyclo-
5 dodecylamine, benzylamine or cyclic or aromatic amines with or without additional heteroatoms such as but not limited to aziridine, azetidine, pyrrolidine, pyrrole, imidazole, tetrazole or morpholine. Amides can be prepared by reacting the corresponding
10 picolinic acid chloride, mixed anhydride, or carboxylic ester of Formula I with ammonia or an appropriate amine.

The terms "alkyl", "alkenyl" and "alkynyl", as well as derivative terms such as "alkoxy", "acyl",
15 "alkylthio" and "alkylsulfonyl", as used herein, include within their scope straight chain, branched chain and cyclic moieties. Unless specifically stated otherwise, each may be unsubstituted or substituted with one or more substituents selected from but not
20 limited to halogen, hydroxy, alkoxy, alkylthio, C₁-C₆ acyl, formyl, cyano, aryloxy or aryl, provided that the substituents are sterically compatible and the rules of chemical bonding and strain energy are satisfied. The terms "alkenyl" and "alkynyl" are
25 intended to include one or more unsaturated bonds.

The term "aryl", as well as derivative terms such as "aryloxy", refers to a phenyl or naphthyl group. The term "heteroaryl", as well as derivative terms such as "heteroaryloxy", refers to a 5- or 6-
30 membered aromatic ring containing one or more heteroatoms, viz., N, O or S; these heteroaromatic

rings may be fused to other aromatic systems. The aryl or heteroaryl substituents may be unsubstituted or substituted with one or more substituents selected from halogen, hydroxy, nitro, cyano, aryloxy, formyl, C₁-C₆ alkyl, C₂-C₆ alkenyl, C₂-C₆ alkynyl, C₁-C₆ alkoxy, halogenated C₁-C₆ alkyl, halogenated C₁-C₆ alkoxy, C₁-C₆ acyl, C₁-C₆ alkylthio, C₁-C₆ alkylsulfinyl, C₁-C₆ alkylsulfonyl, aryl, C₁-C₆ OC(O)alkyl, C₁-C₆ NHC(O)alkyl, C(O)OH, C₁-C₆ C(O)Oalkyl, C(O)NH₂, C₁-C₆ C(O)NHalkyl, or C₁-C₆ C(O)N(alkyl)₂, provided that the substituents are sterically compatible and the rules of chemical bonding and strain energy are satisfied.

Unless specifically limited otherwise, the term halogen includes fluorine, chlorine, bromine, and iodine.

The compounds of Formula I can be made using well-known chemical procedures. The required starting materials are commercially available or readily synthesized utilizing standard procedures.

In general, reduction of picolinate N-oxides can be used to prepare the corresponding picolines. Electrolytic dehalogenation of 5-halogenated picolines can be used to prepare the 5-H (unsubstituted) picolines, and hydrolysis of pyridines substituted at the 2 position by nitriles, amides, esters and other hydrolyzable functionalities can be used to prepare the desired picolines.

4-N-amide, carbamate, urea, sulfonamide, silylamine and phosphoramidate amino derivatives can be prepared by the reaction of the free amino compound

with, for example, a suitable acid halide, chloroformate, carbamyl chloride, sulfonyl chloride, silyl chloride or chlorophosphate. The imine or hydrazone can be prepared by reaction of the free
5 amine or hydrazine with a suitable aldehyde or ketone.

6-Bromo analogs can be prepared by the reduction of several key intermediates, e.g., the corresponding 6-bromo-4-azido, 6-bromo-4-nitro, and 6-bromo-4-nitro pyridine *N*-oxide analogs. These
10 intermediates, in turn, can be prepared either by nucleophilic displacement of 6-bromo-4-halo analogs with NaN_3 or by electrophilic nitration of the corresponding 6-bromopyridine-*N*-oxides. Alternatively, such analogs can be prepared by direct
15 amination of the corresponding 4,6-dibromo analogs.

6-Fluoro analogs can be prepared by direct amination of the corresponding 4,6-difluoro analog.

3- and 5-Alkoxy and aryloxy analogs can be prepared by reduction of the corresponding 4-azido
20 derivatives, which in turn can be prepared by nucleophilic displacement of the corresponding 4-bromopyridines with NaN_3 . The required 3- and 5-alkoxy-4-bromopyridines can be prepared according to literature procedures.

25 6-Alkoxy, alkylthio, aryloxy and heteroaryloxy analogs can be prepared by nucleophilic displacement with alkoxide, thioalkoxide, aryloxide or heteroaryloxide on the appropriate 6-halopyridine.

3- and 5-Alkylthio analogs can be prepared by lithiation of the appropriate chloropyridines at low temperature and sequential treatment with alkyl disulfides and carbon dioxide. Reaction of the
5 resulting picolinic acids with ammonium hydroxide gave the desired products.

6-Cyano analogs can be prepared by amination of the appropriate 4-halo-6-cyanopicolinate. 4-Halo-6-cyanopicolines can be prepared by action of
10 trimethylsilyl cyanide (TMSCN) on the appropriate pyridine *N*-oxide, which can be prepared by hydrogen peroxide mediated oxidation of the corresponding pyridine.

3- and 5-Cyano analogs can be prepared by
15 action of KCN on the appropriate fluoropyridine at high temperature. 3- and 5-Fluoro, bromo, iodo and nitro analogs can be prepared by electrophilic reaction of the unsubstituted precursor with positive halogen or nitro sources such as fluorine gas,
20 bromine, iodine and fuming nitric acid respectively.

6-Trifluoromethyl analogs can be prepared by amination of readily available methyl trifluoromethylpicolinate (oxidative halogenation of the 4-position followed by displacement with ammonia or an amine
25 equivalent) followed by chlorination of the 3- and 5-positions.

3- and 5-Trifluoromethyl analogs can be prepared by standard manipulations known to those skilled in the art starting from the known compounds

2-fluoro-3-chloro-5-trifluoromethylpyridine and 2,5-dichloro-3-trifluoromethylpyridine.

Substituted 4-amino analogs can be prepared by reacting the corresponding 4-halopyridine-2-
5 carboxylate or any other displaceable 4-substituent with the substituted amine.

The compounds of Formula I, obtained by any of these processes, can be recovered by conventional means. Typically, the reaction mixture is acidified
10 with an aqueous acid, such as hydrochloric acid, and extracted with an organic solvent, such as ethyl acetate or dichloromethane. The organic solvent and other volatiles can be removed by distillation or evaporation to obtain the desired compound of Formula
15 I, which can be purified by standard procedures, such as by recrystallization or chromatography.

The compounds of Formula I have been found to be useful pre-emergence and post-emergence herbicides. They can be employed at non-selective
20 (higher) rates of application to control a broad spectrum of the vegetation in an area or at lower rates of application for the selective control of undesirable vegetation. Areas of application include pasture and rangelands, roadsides and rights of ways,
25 and crops such as corn, rice and cereals. It is usually preferred to employ the compounds post-emergence. It is further usually preferred to use the compounds to control a wide spectrum of broadleaf weeds, including Dock species (*Rumex* spp), Canada
30 thistle (*Cirsium arvense*), pigweed species (*Amaranthus* spp.), Senna species (*Cassia* spp.), spurge species

(Euphorbia spp), ragweed species (Ambrosia spp.), Sida species (Sida spp.), field bindweed (Convolvulus arvensis), and knapweed species (Centaurea spp.), among others. Use of the compounds to control undesirable
5 vegetation in grassy areas is especially indicated. While each of the 4-aminopicolinate compounds encompassed by Formula I is within the scope of the invention, the degree of herbicidal activity, the crop selectivity, and the spectrum of weed control obtained
10 varies depending upon the substituents present. An appropriate compound for any specific herbicidal utility can be identified by using the information presented herein and routine testing.

The term herbicide is used herein to mean an
15 active ingredient that kills, controls or otherwise adversely modifies the growth of plants. An herbicidally effective or vegetation controlling amount is an amount of active ingredient which causes an adversely modifying effect and includes deviations
20 from natural development, killing, regulation, desiccation, retardation, and the like. The terms plants and vegetation include germinant seeds, emerging seedlings and established vegetation.

Herbicidal activity is exhibited by the
25 compounds of the present invention when they are applied directly to the plant or to the locus of the plant at any stage of growth or before planting or emergence. The effect observed depends upon the plant species to be controlled, the stage of growth of the
30 plant, the application parameters of dilution and spray drop size, the particle size of solid

components, the environmental conditions at the time of use, the specific compound employed, the specific adjuvants and carriers employed, the soil type, and the like, as well as the amount of chemical applied.

5 These and other factors can be adjusted as is known in the art to promote non-selective or selective herbicidal action. Generally, it is preferred to apply the compounds of Formula I postemergence to relatively immature undesirable vegetation to achieve

10 the maximum control of weeds.

Application rates of 1 to 500 g/Ha are generally employed in postemergence operations; for preemergence applications, rates of 10 to 1000 g/Ha are generally employed. The higher rates designated

15 generally give non-selective control of a broad variety of undesirable vegetation. The lower rates typically give selective control and can be employed in the locus of crops.

The herbicidal compounds of the present

20 invention are often best applied in conjunction with one or more other herbicides to obtain control of a wider variety of undesirable vegetation. When used in conjunction with other herbicides, the presently claimed compounds can be formulated with the other

25 herbicide or herbicides, tank mixed with the other herbicide or herbicides, or applied sequentially with the other herbicide or herbicides. Some of the herbicides that can be employed in conjunction with the compounds of the present invention include

30 sulfonamides such as metosulam, flumetsulam, cloransulam-methyl, diclosulam and florasulam,

sulfonylureas such as chlorimuron, nicosulfuron and
metsulfuron, imidazolinones such as imazaquin,
imazapic, imazethapyr and imazamox, phenoxyalkanoic
acids such as 2,4-D and MCPA, pyridinyloxyacetic acids
5 such as triclopyr and fluroxypyr, carboxylic acids
such as clopyralid and dicamba, dinitroanilines such
as trifluralin and pendimethalin, chloroacetanilides
such as alachlor, acetochlor and metolachlor and other
common herbicides including acifluorfen, bentazon,
10 clomazone, fumiclorac, fluometuron, fomesafen,
lactofen, linuron, isoproturon, and metribuzin.
Particularly preferred combinations are those with
florasulam, 2,4-D and fluroxypyr, which, against some
weed species, may actually exhibit synergy. A
15 synergistic response may also be obtained with
compounds of the present invention when mixed with
auxin transport inhibitors such as diflufenzopyr and
chlorflurenol. The herbicidal compounds of the
present invention can, further, be used in conjunction
20 with glyphosate and glufosinate on glyphosate-tolerant
or glufosinate-tolerant crops. It is generally
preferred to use the compounds of the invention in
combination with herbicides that are selective for the
crop being treated and which complement the spectrum
25 of weeds controlled by these compounds at the
application rate employed. It is further generally
preferred to apply the compounds of the invention and
other complementary herbicides at the same time,
either as a combination formulation or as a tank mix.

30 The compounds of the present invention can
generally be employed in combination with known
herbicide safeners, such as cloquintocet, furilazole,

dichlormid, benoxacor, mefenpyr-ethyl, fenclorazole-ethyl, flurazole, and fluxofenim, to enhance their selectivity. They can additionally be employed to control undesirable vegetation in many crops that have
5 been made tolerant to or resistant to them or to other herbicides by genetic manipulation or by mutation and selection. For example, corn, wheat, rice, soybean, sugarbeet, cotton, canola, and other crops that have been made tolerant or resistant to compounds that are
10 acetolactate synthase inhibitors in sensitive plants can be treated. Many glyphosate and glufosinate tolerant crops can be treated as well, alone or in combination with these herbicides. Some crops (e.g. cotton) have been made tolerant to auxinic herbicides
15 such as 2,4-dichlorophenoxyacetic acid. These herbicides may be used to treat such resistant crops or other auxin tolerant crops.

While it is possible to utilize the 4-amino-picolinate compounds of Formula I directly as
20 herbicides, it is preferable to use them in mixtures containing a herbicidally effective amount of the compound along with at least one agriculturally acceptable adjuvant or carrier. Suitable adjuvants or carriers should not be phytotoxic to valuable crops,
25 particularly at the concentrations employed in applying the compositions for selective weed control in the presence of crops, and should not react chemically with the compounds of Formula I or other composition ingredients. Such mixtures can be
30 designed for application directly to weeds or their locus or can be concentrates or formulations that are normally diluted with additional carriers and

adjuvants before application. They can be solids, such as, for example, dusts, granules, water dispersible granules, or wettable powders, or liquids, such as, for example, emulsifiable concentrates,
5 solutions, emulsions or suspensions.

Suitable agricultural adjuvants and carriers that are useful in preparing the herbicidal mixtures of the invention are well known to those skilled in the art.

10 Liquid carriers that can be employed include water, toluene, xylene, petroleum naphtha, crop oil, acetone, methyl ethyl ketone, cyclohexanone, trichloroethylene, perchloroethylene, ethyl acetate, amyl acetate, butyl acetate, propylene glycol
15 monomethyl ether and diethylene glycol monomethyl ether, methanol, ethanol, isopropanol, amyl alcohol, ethylene glycol, propylene glycol, glycerine, and the like. Water is generally the carrier of choice for the dilution of concentrates.

20 Suitable solid carriers include talc, pyrophyllite clay, silica, attapulgius clay, kaolin clay, kieselguhr, chalk, diatomaceous earth, lime, calcium carbonate, bentonite clay, Fuller's earth, cotton seed hulls, wheat flour, soybean flour, pumice, wood flour,
25 walnut shell flour, lignin, and the like.

It is usually desirable to incorporate one or more surface-active agents into the compositions of the present invention. Such surface-active agents are advantageously employed in both solid and liquid
30 compositions, especially those designed to be diluted

with carrier before application. The surface-active agents can be anionic, cationic or nonionic in character and can be employed as emulsifying agents, wetting agents, suspending agents, or for other purposes. Typical surface-active agents include salts of alkyl sulfates, such as diethanolammonium lauryl sulfate; alkylarylsulfonate salts, such as calcium dodecylbenzenesulfonate; alkylphenol-alkylene oxide addition products, such as nonylphenol-C₁₈ ethoxylate; alcohol-alkylene oxide addition products, such as tridecyl alcohol-C₁₆ ethoxylate; soaps, such as sodium stearate; alkyl naphthalenesulfonate salts, such as sodium dibutyl naphthalenesulfonate; dialkyl esters of sulfosuccinate salts, such as sodium di(2-ethylhexyl) sulfosuccinate; sorbitol esters, such as sorbitol oleate; quaternary amines, such as lauryl trimethylammonium chloride; polyethylene glycol esters of fatty acids, such as polyethylene glycol stearate; block copolymers of ethylene oxide and propylene oxide; and salts of mono and dialkyl phosphate esters.

Other adjuvants commonly used in agricultural compositions include compatibilizing agents, antifoam agents, sequestering agents, neutralizing agents and buffers, corrosion inhibitors, dyes, odorants, spreading agents, penetration aids, sticking agents, dispersing agents, thickening agents, freezing point depressants, antimicrobial agents, and the like. The compositions may also contain other compatible components, for example, other herbicides, plant growth regulants, fungicides, insecticides, and the like and can be formulated with liquid fertilizers or

solid, particulate fertilizer carriers such as ammonium nitrate, urea and the like.

5 The concentration of the active ingredients in the herbicidal compositions of this invention is generally from 0.001 to 98 percent by weight. Concentrations from 0.01 to 90 percent by weight are often employed. In compositions designed to be employed as concentrates, the active ingredient is generally present in a concentration from 5 to 98
10 weight percent, preferably 10 to 90 weight percent. Such compositions are typically diluted with an inert carrier, such as water, before application. The diluted compositions usually applied to weeds or the locus of weeds generally contain 0.0001 to 1 weight
15 percent active ingredient and preferably contain 0.001 to 0.05 weight percent.

The present compositions can be applied to weeds or their locus by the use of conventional ground or aerial dusters, sprayers, and granule applicators,
20 by addition to irrigation water, and by other conventional means known to those skilled in the art.

The following Examples are presented to illustrate the various aspects of this invention and should not be construed as limitations to the claims.

Examples1. Preparation of 4-Amino-3,6-dichloropyridine-2-carboxylic acid (Compound 1)

In a 3-liter (L) beaker was added 2000 grams
5 (g) of hot water, 115.1 g of 50 percent by weight NaOH, and 200 g of wet 4-amino-3,5,6-trichloro-pyridine-2-carboxylic acid (79.4 percent). The solution was stirred for 30 minutes (min), filtered through a paper filter, and transferred to a 5-L
10 feed/recirculation tank. This solution weighed 2315 g and contained 6.8 percent 4-amino-3,5,6-trichloro-pyridine-2-carboxylic acid. This feed was recirculated at a rate of about 9.46 L/min and a temperature of 30°C through an undivided
15 electrochemical cell having a Hastelloy C anode and an expanded silver mesh screen cathode. After normal anodization at +0.7 volt (v), the polarity of the cell was reversed and the electrolysis was started. The cathode working potential was controlled at -1.1 to
20 -1.4 v relative to an Ag/AgCl (3.0 M Cl⁻) reference electrode. While recirculating the feed, a solution of 50 percent NaOH is slowly pumped into the recirculation tank to maintain the NaOH concentration at a 1.5 to 2.0 percent excess. After about 15 hours
25 (hr), the electrolysis was terminated and the cell effluent was filtered through a paper filter. The solution was neutralized with concentrated HCl and concentrated to about 750 g of crude concentrate. The concentrate was warmed to 85°C with stirring and the
30 pH was adjusted to less than 1 with concentrated HCl over 30 min. The resulting slurry was cooled to

ambient temperature and filtered. The filter cake was washed with 3x200 milliliter (mL) portions of water and dried under vacuum at 80°C. The dried product, 118.1 g assayed at 90.6 percent desired product; gas chromatography (GC) indicated about 4 percent 4-amino-3,5,6-trichloropyridine-2-carboxylic acid remaining as an impurity. A purified sample of 4-amino-3,6-dichloropyridine-2-carboxylic acid had a melting point (mp) of 185-187°C (dec.); ¹H NMR (DMSO-d₆): δ 13.9 (br, 1H), 7.0 (br m, 2H), 6.8 (s, 1H); ¹³C NMR {¹H} (DMSO-d₆): δ 165.4 (1C), 153.4 (1C), 149.5 (1C), 147.7 (1C), 111.0 (1C), 108.1 (1C).

2. Preparation of 2-Ethylhexyl 4-amino-3,6-dichloropyridine-2-carboxylate (Compound 2)

To a solution of 2-ethylhexanol (10 mL) and sulfuric acid (1 mL) was added 4-amino-3,6-dichloropyridine-2-carboxylic acid (0.0097 mol, 2.0 g). After heating the reaction to reflux overnight, the reaction mixture was cooled, poured into water (75 mL), and extracted with ethyl acetate (75 mL). The organic phase was washed with sodium bicarbonate (75 mL), dried (Na₂SO₄), and concentrated. The resulting solid was recrystallized out of dichloromethane and hexane and filtered to give 2-ethylhexyl 4-amino-3,6-dichloropyridine-2-carboxylate (0.0074 mol, 2.36 g) as a crystalline solid (mp 55°C). ¹H NMR (CDCl₃): δ 0.9 (7 H, m), 1.3 (7 H, m), 1.7 (1 H, m), 4.3 (2 H, d), 5.1 (2 H, bs), 6.7 (1 H, s).

The following esters of 4-amino-3,5,6-trichloro-pyridine-2-carboxylic acid were prepared according to the procedure of Example 2:

methyl 4-amino-3,6-dichloropyridine-2-carboxylate(Compound 3); mp 134-135°C.

ethyl 4-amino-3,6-dichloropyridine-2-carboxylate(Compound 4); mp 98-99°C.

5 *n*-propyl 4-amino-3,6-dichloropyridine-2-carboxylate(Compound 5); mp 94-95°C.

i-propyl 4-amino-3,6-dichloropyridine-2-carboxylate(Compound 6); mp 114-115°C.

10 *n*-butyl 4-amino-3,6-dichloropyridine-2-carboxylate(Compound 7); mp 78-79°C.

n-pentyl 4-amino-3,6-dichloropyridine-2-carboxylate (Compound 8); mp 71-73°C.

n-hexyl 4-amino-3,6-dichloropyridine-2-carboxylate (Compound 9); mp 65-66°C.

15 butoxyethyl 4-amino-3,6-dichloropyridine-2-carboxylate (Compound 10); mp 64-7°C as the monohydrate.

20 3. Preparation of 4-Amino-3,6-dichloropyridine-2-carboxamide (Compound 11)

To a 250 mL three neck roundbottom flask fitted with a mechanical stirrer were added methyl 750 (10.0 g, 45 mmol) and 28% aq. NH₄OH (35 mL) at 0°C.
25 The suspension was stirred vigorously for 24 hr while warming gradually to 25°C. The suspension was suction filtered, and the filter cake was washed on the filter

with cold water (2 x 100 mL). After air drying on the filter, the analytically pure white solid product was collected to give 4-amino-3,6-dichloropyridine-2-carboxamide 11 (8.58 g, 92% yield); mp 240-241°C.

5 4. Preparation of Methyl N-acetyl 4-amino-3,6-dichloropyridine-2-carboxylate (Compound 12) and N,N-diacetyl 4-amino-3,6-dichloropyridine-2-carboxylate (Compound 13)

10 A solution of acetic anhydride (75 mL) and methyl 4-amino-3,6-dichloropyridine-2-carboxylate (0.00904 mol, 2.0 g) was stirred and heated to reflux overnight. The solution was cooled, concentrated, taken up in ethyl acetate (100 mL), and washed with water (100 mL). The organic phase was washed with
15 saturated sodium bicarbonate (100 mL), dried (Na₂SO₄), and concentrated. The solution was purified by chromatography on silica gel. The front running spot was isolated and gave a yellow oil identified as the diacylated 4-amide Compound 13 (0.0023 mol, 0.700 g).
20 ¹H NMR 2.2 (6 H, s), 3.9 (3 H, s), 7.3 (1 H, s). The second spot gave a yellow solid identified as the monoacylated 4-amide compound 12 (0.0035 mol, 0.920 g); mp 102-103°C.

5. Preparation of 4-Amino-6-bromo-3-chloropyridine-2-carboxylic acid (Compound 14)

5 A. Methyl 6-bromo-3-chloropyridine-2-carboxylate, N-oxide

To a solution of methyl 6-bromo-3-chloro-pyridine-2-carboxylate (0.13 mol, 32.1 g) in trifluoroacetic acid (75 mL) and trifluoroacetic anhydride (40 mL) was cautiously added 50% hydrogen peroxide (0.17 mol, 13 g). The reaction exothermed to reflux. After stirring for 30 min, the solution was poured into a mixture of ice and 10 percent sodium bisulfite (150 mL). The resulting solid was collected and dried *in vacuo* to give a white solid (0.08 mol, 21.4 g). ¹H NMR (CDCl₃): δ 4.1 (3H, s), 7.3 (1H, d), 7.7 (1H, d).

B. Methyl 6-bromo-3-chloro-4-nitropyridine-2-carboxylate, N-oxide

To a solution of fuming nitric acid (10 mL) and fuming sulfuric acid (10 mL) was added methyl 6-bromo-3-chloropyridine-2-carboxylate, N-oxide and the reaction was heated to 70°C in an oil bath for 4 hr. The mixture was poured over ice water (100 mL) and extracted with ethyl acetate (3 x 75 mL) and the combined extracts were backwashed with brine, dried (Na₂SO₄) and concentrated. The dark oil was chromatographed over silica in 4:1 EtOAc/hexane to give methyl 6-bromo-3-chloro-4-nitropyridine-2-carboxylate, N-oxide (0.007 mol, 2.2 g). ¹H NMR (CDCl₃): δ 4.1 (3H, s), 8.4 (1H, s).

C. Methyl 4-amino-6-bromo-3-chloropyridine-2-carboxylate

To a solution of titanium tetrachloride (0.015 mol, 2.8 g) in tetrahydrofuran (50 mL) was
5 added lithium aluminum hydride (0.0175 mol, 0.7 g). The black slurry was stirred 15 min before adding methyl 6-bromo-3-chloro-4-nitropyridine-2-carboxylate, N-oxide (0.007 mol, 2.3 g) in THF (25 mL). The solution was stirred 1 hr before pouring into 1:1
10 H₂O/NH₄OH and filtering. The filtrate was extracted with EtOAc (2 x 75 mL). The organic phase was dried (Na₂SO₄), and concentrated. The red solid was chromatographed over silica in 4:1 EtOAc/hexane to give methyl 4-amino-6-bromo-3-chloropyridine-2-
15 carboxylate (0.003 mol, 0.8 g); mp 194-5°C. ¹H NMR(CDCl₃): δ 3.95 (3H, s), 5.3 (2H, bs), 6.9 (1H, s).

D. 4-Amino-6-bromo-3-chloropyridine-2-carboxylic acid (Compound 14)

To methyl 4-amino-6-bromo-3-chloropyridine-
20 2-carboxylate (200mg; 0.8 mmol) in 10 mL of methanol was added excess 2N NaOH (10 mL). The mixture was stirred for 1 hr at ambient temperature and then evaporated to dryness *in vacuo*. The residue was dissolved in water and diethyl ether. After
25 separation of the phases, the aqueous layer was acidified with 1N HCl to a pH=2. The aqueous layer was evaporated to dryness and the residue was dissolved in 50 mL of methanol and filtered. The filtrate was evaporated under reduced pressure and the
30 residue was triturated with 5 percent diethyl ether in

petroleum ether to give 70 mg of 4-amino-6-bromo-3-chloropyridine-2-carboxylic acid, mp 182-183°C.

6. Preparation of Methyl 4-amino-3-chloro-6-fluoropyridine-2-carboxylate (Compound 15)

5 A. Methyl 3-chloro-4,6-difluoropyridine-2-carboxylate

To a solution of methyl 3,4,6-trichloropyridine-2-carboxylate (0.010 mol, 2.4 g) in DMSO (10 mL) was added cesium fluoride (0.038 mol, 3.8 g) and the suspension was heated for 2 hr at 100°C. The reaction mixture was dissolved in dilute HCl and extracted with ethyl acetate (EtOAc). The organic layer was treated with (trimethylsilyl)diazomethane (TMSCHN₂) to re-esterify any hydrolyzed ester. The mixture was concentrated and the resultant residue was chromatographed over silica with 10 percent EtOAc/hexane to give methyl 3-chloro-4,6-difluoropyridine-2-carboxylate (0.0072 mol, 1.5 g). ¹H NMR (CDCl₃): δ 4.00 (3H, s), 6.95-6.90 (1H, m). ¹⁹F NMR {¹H}: δ -65.0 (d, J = 17 Hz), 95.8 (d, J = 17 Hz).

B. Methyl 4-amino-3-chloro-6-fluoropyridine-2-carboxylate (Compound 15)

Sodium azide (0.0086 mol, 0.60 g) was added to a solution of methyl 3-chloro-4,6-difluoropyridine-2-carboxylate (0.0072 mol, 1.5 g) in 15 mL dimethyl formamide (DMF). The solution was stirred 10 min at ambient temperature before pouring into 350 mL water and extracting the aqueous mixture with EtOAc (2 x 100 mL). The organic phase was dried (Na₂SO₄) and then

treated with excess NaBH_4 for 30 min. The excess NaBH_4 was quenched with aqueous EtOH and the mixture was diluted with water (200 mL). The organic layer was separated and the aqueous layer extracted with EtOAc (2 x 200 mL). The combined organic layers were dried (Na_2SO_4) and concentrated to an off-white powder which was purified by reversed-phase HPLC to give methyl 4-amino-3-chloro-6-fluoropyridine-2-carboxylate (0.0059 mol, 1.2 g). ^1H NMR(CDCl_3): δ 3.95 (3H, s), 5.2-5.1 (2H, bs), 6.36 (1H, s). ^{19}F NMR (^1H): δ -72.7.

7. Preparation of 4-Amino-3,5-difluoro-6-bromopyridine-2-carboxylic acid (Compound 16)

15 A. Preparation of 4-Amino-3,5,6-trifluoro-2-cyanopyridine

To a solution of 3,4,5,6-tetrafluoro-2-cyanopyridine in DMF (75 mL) at 0°C was slowly added concentrated ammonium hydroxide (15 mL). The reaction was stirred and additional 15 min and the solution was diluted with water (150 mL). The solid was collected and air dried to give 4-amino-3,5,6-trifluoro-2-cyanopyridine (25.5 g, 0.16 mol, 92%); mp $291-3^\circ\text{C}$.

25 B. Preparation of Methyl, 4-amino-6-bromo-3,5-difluoropyridine-2-carboxylate (Compound 16)

A solution of 4-amino-3,5,6-trifluoro-2-cyanopyridine (19 g, 0.12 mol) in thirty percent hydrogen bromide in acetic acid (150 mL) was placed in a Paar bomb and heated to 110°C for 3 hr. The

reaction was diluted with water (300 ml) and the solid (4-amino-6-chloro-3,5-difluoropyridine-2-carboxamide) was collected. This material, without further purification, was slurried in methanol (500 ml) and concentrated hydrochloric acid added. The slurry was heated under reflux for 4 hr and, after cooling to room temperature, diluted with water (1,000 mL) and the solid collected and dried to give methyl 4-amino-6-bromo-3,5-difluoropyridine-2-carboxylate (9.6 g, 0.04 mol, 25%); mp 110-111°C.

8. Preparation of 4-Amino-3,6-dibromopyridine-2-carboxylic acid (Compound 17)

3,4,5,6-Tetrabromopyridine-2-carboxamide (5.0 g) was selectively aminated with ammonia gas at RT in 100 mL methanol. The resultant solution was concentrated to an off-white solid and hydrolyzed with conc. sulfuric acid (25 mL) at 140°C for 3 hr. the mixture was made basic with NaOH, extracted with EtOAc (2 x 100 mL), acidified and filtered to give 1.4 g of pure 4-amino-3,6-dibromopyridine-2-carboxylic acid; mp 205°C dec.

9. Preparation of Methyl 4-amino-3,5,6-tribromopyridine-2-carboxylate (Compound 18)

Methyl 4-amino-3,5,6-tribromopyridine-2-carboxylate was prepared by amination of methyl 3,4,5,6-tetrabromopyridine-2-carboxylate following the procedure of Example 6B. ¹H NMR(CDCl₃): δ 3.95 (3H, s), 6.9-6.8 (2H, bs).

10. Preparation of 4-Amino-3,6-dichloro-5-fluoropyridine-2-carboxylic acid (Compound 19)

To a solution of 4-amino-3,6-dichloro-pyridine-2-carboxylate (1.5 g, 6.8 mmol) in 20 mL of
5 dry acetonitrile was added 1-(chloromethyl)-4-fluoro-1,4-diazoniabicyclo[2.2.2]octane bis(tetrafluoroborate) (Selectfluor™ from Aldrich Chemical Company, Inc.; 2.9 g, 2.59 mmol [F⁺]/g). The resulting mixture was heated at reflux for 3 hr, then
10 allowed to cool to room temperature. This material was taken up in Et₂O and washed with H₂O. The organic layer was dried over MgSO₄, filtered and concentrated to yield a brown oil. The crude product was purified
15 via reverse phase HPLC (50% acetonitrile/water) to give 0.37 g of white solid which was stirred in 1N NaOH for 1 hr then made acidic with conc. HCl. The precipitated white solid was collected with suction, washed with H₂O and dried under vacuum to give 170 mg
20 of 4-amino-3,6-dichloro-5-fluoropyridine-2-carboxylic acid (11% yield); mp 214°C dec.

11. Preparation of 4-Amino-3,6-dichloro-5-bromopyridine-2-carboxylic acid (Compound 20)

To a solution of methyl 4-amino-3,6-dichloropyridine-2-carboxylate (18 g, 81 mmol) in 100
25 mL fuming sulfuric acid was added bromine (15 mL, excess). The resulting mixture was heated to 70°C for 30 min, then allowed to cool to room temperature. This material was poured into ice water (1000 mL) and extracted with EtOAc (4 x 500 mL). The combined
30 organic extracts were dried (MgSO₄), filtered and concentrated to yield a brown solid. The crude

product was purified via reverse phase HPLC (50% acetonitrile/water) to give 21 g of 4-amino-3,6-dichloro-5-bromopyridine-2-carboxylic acid as a white solid (91% yield); mp 201-202°C.

5 12. Preparation of 4-Amino-3,6-dichloro-5-trifluoromethylpyridine-2-carboxylic acid (Compound 21)

 A solution of 4-amino-3,6-dichloro-5-trifluoromethyl-2-cyanopyridine (0.5 g, 1.96 mmol) in
10 10 mL of 85% H₂SO₄ was stirred at 140°C for 0.5 hr. The reaction mixture was allowed to cool and added to ice. The precipitated white solid was collected with suction, rinsed several more times with water and allowed to air dry to give 0.33 g of product as a
15 white solid (61.4% yield); mp 173°C.

13. Preparation of 4-Amino-3,6-dichloro-5-methoxypyridine-2-carboxylic acid (Compound 22)

 A. Methyl 3-chloro-5-methoxypyridine-2-carboxylate, N-oxide

20 In a dry 3-neck round bottom flask was added methyl 3,5-dichloropyridine-2-carboxylate, N-oxide (5.0 g, 22.5 mmol) to 25 mL of methanol to give a slurry. A 25% solution of sodium methoxide in methanol (5.40 mL, 23.62 mmol) was added and heated to reflux
25 for 1.5 h. The reaction mixture was diluted in ethyl acetate and added to H₂O. The layers were separated and the aqueous layer was saturated with brine and extracted 2 more times in ethyl acetate. The combined organic layers were dried (MgSO₄) and concentrated to

give a white solid. Purification by column chromatography (silica gel) using an eluent of 50% Et₂O/Petroleum ether (1.5 L) then 100% Et₂O to give 1.76 g of a white solid; mp 154-156°C.

5 B. Methyl 3-chloro-5-methoxy-4-nitropyridine-2-carboxylate, N-oxide

To methyl 3-chloro-5-methoxypyridine-2-carboxylate, N-oxide (1.41 g, 5.97 mmol) in H₂SO₄ cooled to 0°C was slowly added a 50/50 mixture of 30%
10 oleum and fuming HNO₃. Reaction mixture stirred for 30 min at room temperature and then heated to 70°C for 3 days. The reaction mixture was diluted with ethyl acetate and cooled to 0°C. Saturated sodium bicarbonate was carefully added and the layers were
15 separated. Aqueous layer was washed 2 more times with ethyl acetate. The combined organic layers were dried (MgSO₄) and concentrated to dryness. Purification by column chromatography (silica gel) using an eluent of 20% ethyl acetate/hexane gave 300 mg of a yellow
20 solid; mp 160°C.

C. Methyl 3,6-dichloro-5-methoxy-4-nitropyridine-2-carboxylate

To methyl 3-chloro-5-methoxy-4-nitropyridine-2-carboxylate, N-oxide (0.300 g, 1.12 mmol)
25 in 5 mL of chloroform was added PCl₃ (0.664 mL, 7.62 mmol). The reaction mixture was heated to reflux for 8 hr and then concentrated to dryness *in vacuo* to give 300 mg of a white solid.

D. Methyl 4-amino-3,6-dichloro-5-methoxypyridine-2-carboxylate

To methyl 3,6-dichloro-5-methoxy-4-nitropyridine-2-carboxylate (0.300 g, 1.06 mmol) in 5 mL of ethyl acetate was added $\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$ (1.60 g, 7.1 mmol). The reaction mixture was heated to 70°C for 30 min and then cooled to room temperature. Saturated sodium bicarbonate and a saturated solution of KHF_2 were added to reaction mixture. The mixture was extracted with ethyl acetate and the layers were separated. The aqueous layer was washed 2 more times with ethyl acetate. The combined organic layers were dried (MgSO_4) and concentrated to dryness to give 0.250 g of a yellow solid.

E. 4-Amino-3,6-dichloro-5-methoxypyridine-2-carboxylic acid (Compound 22)

4-Amino-3,6-dichloro-5-methoxypyridine-2-carboxylic acid was prepared by saponification of the methyl ester according to the procedure of Example 17(D); mp 154-156°C.

14. Preparation of 4-Amino-3,6-dichloro-5-methylthiopyridine-2-carboxylic acid (Compound 23)

4-Amino-3,6-dichloro-5-methylthiopyridine-2-carboxylic acid was prepared by analogy to the preparation of 4-amino-3,6-dichloro-5-methoxypyridine-2-carboxylic acid following the procedure of Example 13 using sodium thiomethoxide instead of sodium methoxide; mp 160°C dec.

15. Preparation of 4-Amino-3,6-dichloro-5-phenylthio-
pyridine-2-carboxylate (Compound 24)

4-Amino-3,6-dichloro-5-phenylthiopyridine-2-carboxylic acid was prepared by analogy to the
5 preparation of 4-amino-3,6-dichloro-5-methoxypyridine-2-carboxylic acid following the procedure of Example 13 using sodium thiophenoxide instead of sodium methoxide; mp 160°C dec.

10 16. Preparation of Methyl 4-amino-3,6-dichloro-5-nitropyridine-2-carboxylate (Compound 25)

To a solution containing 4-amino-3,6-dichloropyridine-2-carboxylic acid (0.5 g, 2.43 mmol) and 10 mL of conc. H₂SO₄ was added dropwise a mixture
15 of conc. HNO₃/H₂SO₄ (1 mL/ 1 mL) at RT. After stirring for 5 min, the reaction mixture was added to ice and the solid was collected by vacuum filtration. The resulting solid was dissolved in 20% MeOH/EtOAc and trimethylsilyl diazomethane (TMSCHN₂) was then added
20 until reaction was complete. Reaction mixture was concentrated under reduced pressure, taken up in Et₂O and washed with aqueous NaHCO₃, dried over MgSO₄, filtered and concentrated to give a brown oil. The crude product was purified by chromatography, eluting
25 with 10% ethyl acetate-hexane to give 80 mg of the methyl ester as a yellow solid; mp 127-8°C.

17. Preparation of 4-N-Methylamino-3,6-dichloropyridine-2-carboxylic acid (Compound 26)

A. Methyl 3,6-dichloropyridine-2-carboxylate

To a 3-neck round bottom flask equipped with
5 a reflux condenser was added 3,6-dichloropyridine-2-carboxylic acid (50.0 g, 260.42 mmol) in methanol (200 mL). HCl_(g) was bubbled in until solution became saturated and stirred at room temperature for 2 hr. The solution was concentrated to dryness *in vacuo*.
10 Diethyl ether was added to make a slurry that was subsequently added to a flask filled with a 1:1 mixture of saturated sodium bicarbonate/diethyl ether and stirred for 10 min. The aqueous phase was extracted with diethyl ether (3 X 300 mL). The
15 combined extracts were dried (MgSO₄) and concentrated to give 46.6 g of a light yellow solid. ¹H NMR(CDCl₃):
δ 4.00 (s, 3H); 7.41 (d, 1H); 7.80 (d, 1H).

B. Methyl 3,6-dichloropyridine-2-carboxylate, N-oxide

20 Methyl 3,6-dichloropicolinate (20.0 g, 97.07 mmol) was dissolved in a minimum amount of trifluoroacetic acid (TFA). In a separate flask was stirred trifluoroacetic anhydride (TFAA, 38 mL) and
50% H₂O₂ (9.9 g, 145.61 mmol) which was added to the
25 TFA solution. The reaction mixture was stirred at reflux for 1 hr and concentrated to dryness. The orange oil was dissolved in ethyl acetate and saturated sodium bicarbonate. The phases were separated and the aqueous phase was extracted with
30 ethyl acetate (2 X 200mL). The combined extracts were

dried (MgSO_4) and concentrated to a yellow solid. Purification by column chromatography (silica gel) using an eluent of 50% ethyl acetate/hexane gave 12.13 g of a yellow solid. ^1H NMR (CDCl_3): δ 4.00 (s, 3H);
5 7.25 (d, 1H); 7.50 (d, 1H).

C. Methyl 3,4,6-Trichloropyridine-2-carboxylate

To methyl 3,6-dichloropicolinate *N*-oxide (5.0 g, 22.52 mmol) dissolved in 15 mL of acetonitrile was added POCl_3 (4.20 mL, 45.04 mmol). The reaction
10 mixture was stirred at reflux for 5 hr, cooled to room temperature and concentrated to dryness *in vacuo*. The resultant orange oil was dissolved in diethyl ether. Carefully, saturated sodium bicarbonate was added and the aqueous phase was extracted with diethyl ether (2
15 X 100 mL). The combined extracts were dried (MgSO_4) and concentrated to dryness. Purification by column chromatography (silica gel) using an eluent of 20% ethyl acetate/hexane gave 5.89 g of a light yellow solid. ^1H NMR(CDCl_3): δ 4.00 (s, 3H); 7.55 (s, 1H).

20 D. 3,4,6-Trichloropyridine-2-carboxylic acid

To methyl 3,4,6-Trichloropicolinate (3.57 g, 14.85 mmol) in 20 mL of methanol was added 1N NaOH (14.85 mL, 14.85 mmol). The reaction mixture was stirred at room temperature for 1 hr and then
25 concentrated to dryness *in vacuo*. 100 mL each of diethyl ether and H_2O were added. Aqueous layer was acidified with 1N HCl until pH=2. Methylene chloride was added and the aqueous phase was extracted with additional CH_2Cl_2 (2 X 100 mL). The combined extracts

were dried (MgSO_4) and concentrated to give 3.13 g of a white solid. ^1H NMR(CDCl_3): δ 7.50 (s, 1H).

E. 4-N-Methylamino-3,6-dichloropyridine-2-carboxylic acid (Compound 26)

5 3,4,6-Trichloropyridine-2-carboxylic acid (1.56 g, 6.89 mmol) was dissolved in methylamine and placed in a Parr bomb at 80°C for 2 days. The reaction mixture was cooled to room temperature and diluted with ethyl acetate. 1N HCl was added until
10 pH=2. The aqueous phase was extracted with ethyl acetate (2 X 50 mL) and the combined extracts were dried (MgSO_4) and concentrated to dryness. Desired product was triturated from 5% diethyl ether/pet
15 ether; the solid was filtered and dried to give 0.600 g of a light yellow solid. ^1H NMR(CDCl_3): δ 2.75 (s, 3H); 5.70 (s, 1H); 6.30 (s, 1H); mp $170\text{--}172^\circ\text{C}$.

The following N-alkyl analogs of 4-amino-3,6-dichloropyridine-2-carboxylic acid were prepared according to the procedure of Example 17:

20 4-N-ethylamino-3,6-dichloropyridine-2-carboxylic acid (Compound 27); mp $136\text{--}137^\circ\text{C}$.

4-N-isopropylamino-3,6-dichloropyridine-2-carboxylic acid (Compound 28); mp $146\text{--}147^\circ\text{C}$.

25 4-N-butylamino-3,6-dichloropyridine-2-carboxylic acid (Compound 29); mp $96\text{--}97^\circ\text{C}$.

4-N-allylamino-3,6-dichloropyridine-2-carboxylic acid (Compound 30); mp $128\text{--}131^\circ\text{C}$.

4-*N*-hydroxyethylamino-3,6-dichloropyridine-2-carboxylic acid (Compound 31); mp 140-141°C.

4-*N*-methoxyethylamino-3,6-dichloropyridine-2-carboxylic acid (Compound 32); mp 97-99°C.

5 4-*N,N*-dimethylamino-3,6-dichloropyridine-2-carboxylic acid (Compound 33); mp 110°C.

4-*N*-hydroxy-*N*-methyl-amino-3,6-dichloropyridine-2-carboxylic acid (Compound 34); mp 140-1°C.

10 4-*N*-methoxy-*N*-methyl-3,6-dichloropyridine-2-carboxylic acid (Compound 35); mp 98-99°C.

4-pyrrolidino-3,6-dichloropyridine-2-carboxylic acid (Compound 36); mp 153-5°C.

15 4-pyrrolo-3,6-Dichloropyridine-2-carboxylic acid (Compound 37); mp 155-156°C.

18. Preparation of Methyl 4-azido-6-bromo-3-chloropyridine-2-carboxylic acid (Compound 38)

20 To a solution of methyl 4,6-dibromo-3-chloropyridine-2-carboxylate (6.0 g 0.018 mol) in DMF (50 mL) was added sodium azide (2.0 g 0.03 mol) and the solution warmed to 50°C for 1 hr. The reaction was diluted with water (200 mL) and cooled to 0°C for
25 1 hr. The solid was collected to give methyl 4-azido-6-bromo-3-chloropyridine-2-carboxylate (4.4 g, 0.012 mol, 66%); mp 84-86°C

19. Preparation of 4-Nitro-3,6-dichloropyridine-2-
5 carboxylic acid (Compound 39)

Methyl 3,6-dichloropyridine-2-carboxylate *N*-oxide (5.0 g, 22.52 mmol) was dissolved in a minimum amount of H₂SO₄. The mixture was cooled in an ice/water
10 bath and to it was slowly added 30% oleum (9.6 mL) and fuming HNO₃ (9.6 mL), gradually heated to 65°C and stirred for 48 hr. The cooled reaction mixture was diluted with ethyl acetate (200 mL) and to it was carefully added saturated sodium bicarbonate. The
15 product was extracted with ethyl acetate (2 X 150 mL) and the combined extracts were dried (MgSO₄) and concentrated to give 0.10 g of a yellow solid; mp 192-193°C

20. Preparation of 4-*N,N*-Dimethylformamidino-3,6-
20 dichloropyridine-2-carboxylic acid (Compound 40)

To a suspension of methyl 4-amino-3,6-dichloro-pyridine-2-carboxylic acid (2.07 g, 10.0
25 mmol) in THF (50 mL) was added 5.0 eq *N,N*-dimethylformamide dimethyl acetal (50 mmol). The mixture was heated to 50°C for 1 hr during which time the suspension became a homogeneous solution. The cooled reaction mixture was concentrated *in vacuo*,
30 triturated with hexanes to a white amorphous solid and dried under high vacuum to give 2.5 g of a highly

hygroscopic white powder (95% yield); ^1H NMR (DMSO) δ 8.21 (1H, s), 7.95 (1H, s), 3.25 (3H, s), 3.17 (3H, s).

5 21. Preparation of 4-Amino-6-bromo-3-methoxypyridine-2-carboxylic acid (Compound 41)

10 A. Methyl 4,6-dibromo-3-methoxypyridine-2-carboxylate

To methyl 4,6-dibromo-3-hydroxypyridine-2-carboxylate 3.98 g (3.98 g, 12.81 mmol) in 40 mL of acetone was added K_2CO_3 (2.0 g, 14.47 mmol) and dimethyl sulfate (1.20 mL, 12.37 mmol). The reaction mixture was refluxed overnight and concentrated to dryness. The residue was dissolved in ethyl acetate and saturated sodium bicarbonate. The phases were separated and the aqueous phase was extracted with ethyl acetate (3 X 100 mL). The combined extracts were dried (MgSO_4) and concentrated to dryness. The residue was purified by chromatography (silica gel). Elution with 15% ethyl acetate/hexane gave 0.980 g, of a white solid. ^1H NMR(CDCl_3): δ 3.95 (s, 3H); 3.90 (s, 3H); 7.80 (s, 1H).

25 B. Methyl 4-azido-6-bromo-3-methoxypyridine-2-carboxylate

Methyl 4,6-dibromo-3-methoxypyridine-2-carboxylate (0.980 g, 3.02 mmol) was dissolved in a minimum amount of DMF. Slowly sodium azide (0.216 g, 3.32 mmol) was added followed by H_2O to form a

30

homogeneous solution. The reaction mixture was heated to 60°C and stirred for 2 days. Reaction mixture added to a flask filled with ice water and extracted with ethyl acetate (3 X 50 mL). Extracts were
5 combined and back washed with H₂O, dried (MgSO₄) and concentrated to give 0.500 g of an orange oil. ¹H NMR(CDCl₃): δ 3.90 (s, 3H); 3.95 (s, 3H); 7.20 (s, 1H).

10 C. Methyl 4-amino-6-bromo-3-methoxypyridine-2-carboxylate

To methyl 4-azido-6-bromo-3-methoxypyridine-2-carboxylate (0.500 g, 1.74 mmol) in 10 mL of methanol was added NaBH₄ (0.046 g, 1.22 mmol). The reaction mixture was stirred at room temperature for
15 10 min. Ethyl acetate and water were added and the phases were separated. The organic phase was washed with H₂O, dried (MgSO₄) and concentrated to dryness *in vacuo*. The residue was purified by chromatography (silica gel). Elution with 100% ethyl acetate gave
20 0.300 g of a white solid. ¹H NMR(CDCl₃): δ 3.90 (s, 1H); 3.95 (s, 1H); 4.60 (s, 2H); 6.85 (s, 1H).

D. 4-Amino-6-bromo-3-methoxypyridine-2-carboxylic acid (Compound 41)

To methyl 4-amino-6-bromo-3-methoxypyridine-2-carboxylate (0.300 g, 1.15 mmol) in 10 mL of
25 methanol was added 1N NaOH (1.15 mL, 1.15 mmol). The reaction mixture was stirred at room temperature for 1 hr and concentrated to dryness *in vacuo*. Diethyl ether and H₂O were added. The aqueous layer was
30 acidified with 1N HCl until pH=2 and concentrated to

dryness. Methanol (50 mL) was added to the white solid. The mixture was filtered and the filtrate concentrated to dryness. Triturating with 5% diethyl ether/pet ether gave 0.180 g of a light pink solid. ¹H
5 NMR(DMSO): δ 3.60 (s, 3H); 6.80 (s, 1H).

22. Preparation of 4-Amino-6-bromo-5-chloro-3-methoxypyridine-2-carboxylic acid (Compound 42)

A. Methyl 4-amino-6-bromo-5-chloro-3-methoxypyridine-2-carboxylate

10 To methyl 4-amino-6-bromo-3-methoxypyridine-2-carboxylate (1.45 g, 5.56 mmol) in 10 mL of acetonitrile was added sulfuryl chloride, in excess, via pipette until the solution remained yellow. The solution was heated to reflux for 5 min. The reaction
15 mixture was added to saturated sodium bicarbonate and aqueous phase was extracted with diethyl ether (3 x). The combined organic extracts were dried (MgSO₄), filtered and concentrated *in vacuo* to give a yellow solid. Solid was washed in 10% diethyl
20 ether/petroleum ether and solid filtered to give 0.580 g of a white solid.

B. 4-Amino-6-bromo-5-chloro-3-methoxypyridine-2-carboxylic acid (Compound 42)

To methyl-4-amino-6-bromo-5-chloro-3-methoxypyridine-2-carboxylate (0.300 g, 1.02 mmol) in
25 10 mL of methanol was added 1 N NaOH (1.10 mL, 1.10 mmol). The reaction mixture was stirred at room temperature for 4 hr and was then concentrated to dryness *in vacuo*. The resulting aqueous layer was

acidified with concentrated HCl. The white solid was collected by filtration and was rinsed with H₂O. The solid was dried at 50°C under vacuum to give 0.230 g of a white fluffy solid; mp 154-156°C.

5 23. Preparation of 4-Amino-5,6-dichloro-3-fluoropyridine-2-carboxylic acid (Compound 43)

 A. 4-Amino-5,6-dichloro-2-trichloromethylpyridine

 To a solution of 4,5,6-trichloro-2-
10 trichloromethylpyridine (2 g, 6.7 mmol) in aqueous DMF was added NaN₃ (0.5 g, 7.7 mmol). The resulting mixture was heated at 70°C for 2 hr, added to H₂O and extracted (3x) with Et₂O. Organic layer was concentrated to yield a white solid, which was
15 dissolved in 10 mL of MeOH. Excess NaBH₄ was added and the reaction mixture was stirred at room temperature for 0.5 hr. This material was added to H₂O, extracted (3x) with Et₂O, dried over MgSO₄ and concentrated in vacuo. The resulting solid was washed several times
20 with hexane to give 1.3 g of 4-amino-5,6-dichloro-2-trichloromethylpyridine.

 B. 4-Amino-5,6-dichloro-3-fluoropyridine-2-carboxylic acid (Compound 43)

 To a solution of 4-amino-5,6-dichloro-2-
25 trichloromethylpyridine (1.25 g, 4.46 mmol) in 20 mL of dry acetonitrile was added Selectfluor™ (1.9 g, 2.59 mmol [F⁺]/g). The resulting mixture was heated at reflux for 72 hr, then allowed to cool to room temperature. This material was taken up in Et₂O and

washed with H₂O. The organic layer was dried over MgSO₄, filtered and concentrated to yield a dark oil. The crude product was purified via reverse phase HPLC (75% acetonitrile/water) to give 0.2 g of white solid
5 which was stirred in 80% H₂SO₄ at 155°C for 0.5 hr. Reaction mixture was allowed to cool and extracted several times with 10% MeOH/CH₂Cl₂. Organic layer was dried over MgSO₄, filtered and concentrated to give a white solid which was washed several times with
10 hexane-diethyl ether to give 60 mg of 4-amino-5,6-dichloro-3-fluoropyridine-2-carboxylic acid; mp 208°C dec.

24. Preparation of 4-Amino-3-bromo-6-chloropyridine-2-carboxylic acid (Compound 44)

15 A. Methyl 3-bromo-4-chloropyridine-2-carboxylate

To a solution of 3-bromo-4-chloropyridine-2-carboxylic acid (1.75 g, 7.4 mmol) in MeOH was added anhydrous HCl. The resulting mixture was stirred at room temperature for 18 hr. The reaction mixture was
20 concentrated to give a solid, which was partitioned between Et₂O and saturated NaHCO₃. Organic layer was dried over MgSO₄, filtered and concentrated to give a brown residue. This material was purified via flash column chromatography to yield 1.35 g of product as a
25 pale yellow oil.

B. Methyl 3-bromo-4,6-dichloropyridine-2-carboxylate

To a solution of methyl 3-bromo-4-chloropyridine-2-carboxylate (1.35 g, 5.4 mmol) in 5

mL of TFA was added 30% H₂O₂ (1 g, 9.8 mmol). The resulting mixture was stirred at 75°C for 0.5 hr and allowed to cool to room temperature. Et₂O was added and the organic layer was washed carefully with
5 saturated NaHCO₃, dried over MgSO₄, filtered and concentrated to give the corresponding N-Oxide intermediate as a white solid. This material was taken up in acetonitrile (5 mL), POCl₃ (2-3 mL) and heated at reflux for 2 hr. The reaction mixture was
10 allowed to cool, added to Et₂O and washed carefully with saturated NaHCO₃, dried over MgSO₄, filtered and concentrated to give 0.9 g of product as a light brown oil. This material was sufficiently pure to carry on to the next step.

15 C. 4-Amino-3-bromo-6-chloropyridine-2-carboxylic acid (Compound 44)

To a solution of methyl 3-bromo-4,6-dichloropyridine-2-carboxylate (0.9 g, 3.2 mmol) in aqueous DMF was added NaN₃ (0.25 g, 3.8 mmol). The
20 resulting mixture was heated at 60°C for 1 hr, added to H₂O and extracted (3x) with Et₂O. Organic layer was concentrated to yield a white solid, which was dissolved in 10 mL of MeOH. Excess NaBH₄ was added and the reaction mixture stirred at room temperature for
25 0.5 hr. This material was added to H₂O, extracted (3x) with Et₂O, dried over MgSO₄ and concentrated. The resulting solid was stirred in 1N NaOH for 1 hr, made acidic with conc. HCl and concentrated to dryness. This material was extracted with MeOH, concentrated to
30 give 220 mg of 4-amino-3-bromo-6-chloropyridine-2-carboxylic acid; mp 175°C dec.

25. Preparation of 4-Amino-3,5-dichloro-6-trifluoro-
methylpyridine-2-carboxylic acid (Compound 45)

5 A. Methyl 4-chloro-6-trifluoromethylpyridine-2-
carboxylate

To a solution of 6-trifluoromethylpicolinic acid (8.6 g, 45 mmol; prepared from the corresponding 6-trifluoromethyl-2-cyanopyridine) in 25 mL of TFA was
10 added 30% H₂O₂ (7.8 g, 67.5 mmol). Reaction mixture was stirred at 70°C for 18 h and concentrated to give 8.0 g of the N-oxide. This material was stirred in HCl/MeOH solution for 18 hr. The reaction mixture was concentrated to give an oily residue which was
15 partitioned between Et₂O and saturated NaHCO₃. The organic layer was dried over MgSO₄, filtered and concentrated to give 5.0 g of a yellow oil. Neat POCl₃ was added and stirred at reflux for 2 hr. The mixture was allowed to cool, added carefully to saturated
20 NaHCO₃ and extracted (3x) with Et₂O. The organic layer was dried over MgSO₄, filtered and concentrated to give a brown solid. This material was purified via flash column chromatograph to give 2.64 g of product as a white solid; mp 62-3°C.

25

B. Methyl 4-amino-6-trifluoromethylpyridine-2-
carboxylate

To a solution of methyl 4-chloro-6-
30 trifluoromethylpyridine-2-carboxylate (2.44 g, 10.2 mmol) in aqueous DMF was added NaN₃ (0.7 g, 10.8 mmol).

The resulting mixture was heated at 70°C for 18 hr, added to H₂O and extracted (3x) with Et₂O. The organic layer was concentrated to yield a white solid that was dissolved in 10 mL of MeOH. Excess NaBH₄ was added and the reaction mixture stirred at RT for 0.5 hr. This material was added to H₂O, extracted (3x) with Et₂O. The extract was dried over MgSO₄ and concentrated. The resulting residue was purified via flash column chromatography to give 0.95 g of product as a white solid; mp 114°C.

C. Methyl 4-amino-3,5-dichloro-6-trifluoromethylpyridine-2-carboxylate

To a solution of methyl 4-amino-6-trifluoromethylpyridine-2-carboxylate (0.75 g, 3.4 mmol) in 5 mL of dry acetonitrile was added SO₂Cl₂ (0.55 mL, 6.8 mmol). The resulting mixture was heated at reflux for 0.5 hr, then allowed to cool to room temperature. This material was taken up in Et₂O and washed with saturated NaHCO₃. The organic layer was dried over MgSO₄, filtered and concentrated to give solid. The crude material was purified via flash column chromatography to yield 0.28 g of product as a white solid; mp 135-6°C.

D. Preparation of 4-Amino-3,5-dichloro-6-trifluoromethylpyridine-2-carboxylate (Compound 45)

To a solution of methyl 4-amino-3,5-dichloro-6-trifluoromethylpyridine-2-carboxylate (0.16

g, 0.56 mmol) in 5 mL of MeOH was added excess 1N NaOH. The resulting reaction mixture was stirred at room temperature for 1 hr, then made acidic with conc. HCl. The precipitated white solid was collected with suction, washed with H₂O and dried under vacuum to give 80 mg of compound 45; mp 178°C dec.

26. Preparation of 4-Amino-3-chloro-6-trifluoromethylpyridine-2-carboxylic acid (Compound 46)

To a solution containing 4-amino-6-trifluoromethylpyridine-2-carboxylic acid methyl ester (0.75 g, 3.4 mmol) in 5 mL of CH₃CN was added dropwise a solution of sulfuryl chloride (0.27 mL, 3.4 mmol) in 1 mL of CH₃CN. After stirring at RT for 1hr, reaction mixture was added to 50 mL of Et₂O and washed with aqueous NaHCO₃, dried over MgSO₄, filtered and concentrated to give a solid. The crude product was purified by chromatography, eluting with 10% ethyl acetate-hexane to give 200 mg of product as a white solid; mp 131-3°C.

27. Preparation of 4-Amino-3-chloro-6-(3,5-dichlorophenoxy)pyridine-2-carboxylic acid (Compound 47)

A. Preparation of Methyl 3-chloro-6-(3,5-dichlorophenoxy)pyridine-2-carboxylate N-oxide

To a dry 3-neck round bottom flask was added 60% NaH (0.432 g, 10.81 mmol), dry THF (30 mL) and 3,5-dichlorophenol (1.76 g, 10.81 mmol). The mixture was stirred until evolution of H₂ (g) ceased. Methyl

3,6-dichloropyridine-2-carboxylate *N*-oxide (2.0 g, 9.00 mmol) was added in one portion and stirred at RT for 3 hr, diluted with ethyl acetate and 100 mL of water. The aqueous phase was extracted with ethyl acetate (2 X 200 mL). The combined extracts were dried (MgSO₄) and concentrated to give 2.40 g of white solid.

B. Preparation of Methyl 3,4-dichloro-6-(3,5-dichlorophenoxy)pyridine-2-carboxylate

To Methyl 3-chloro-6-(3,5-dichlorophenoxy)pyridine-2-carboxylic acid *N*-oxide (2.40 g, 6.89 mmol) dissolved in 50 mL of acetonitrile was added POCl₃ (1.28 mL, 13.77 mmol). The mixture was stirred at reflux overnight after which it was cooled to RT and concentrated to dryness *in vacuo*. The resultant orange oil was dissolved in diethyl ether and saturated sodium bicarbonate was added *carefully*. The aqueous phase was extracted with diethyl ether (2 X 100 mL). The combined organic extracts were dried (MgSO₄) and concentrated to dryness. Purification by column chromatography (silica gel) using an eluent of 20% diethyl ether/hexane gave 1.93 g of white solid.

25

C. Preparation of Methyl 4-amino-3-chloro-6-(3,5-dichlorophenoxy)pyridine-2-carboxylate

Methyl 3,4-dichloro-6-(3,5-dichlorophenoxy)pyridine-2-carboxylic acid (1.93 g, 5.26 mmol) was dissolved in a minimum amount of DMF and to it was

30

carefully added NaN_3 (0.444 g, 6.84 mmol) and water to form a homogeneous mixture which was heated to 70°C and stirred overnight. The reaction mixture was poured into a water-ice mixture and the product was
5 extracted with ethyl acetate (3 X 100 mL). The combined extracts were washed with pet ether/water (200 mL), dried (MgSO_4) and concentrated to dryness *in vacuo*. The resulting oil was dissolved in methanol and to it was added NaBH_4 (0.200 g, 5.26 mmol) and
10 stirred at RT for 1.5 hr. Ethyl acetate and water was added and the aqueous phase was extracted with ethyl acetate (2 X 100 mL). The combined extracts were dried (MgSO_4) and concentrated to dryness. Purification by column chromatography (silica gel)
15 using an eluent of 20% diethyl ether/hexane-50% diethyl ether/hexane to give 0.900 g of clear solid.

D. Preparation of 4-Amino-3-chloro-6-(3,5-dichlorophenoxy)pyridine-2-carboxylic acid (Compound
20 47)

To Methyl 4-amino-3-chloro-6-(3,5-dichlorophenoxy)pyridine-2-carboxylic acid (0.0.720 g, 2.07 mmol) in 20 mL of methanol was added 1N NaOH
25 (2.07 mL) and stirred at RT for 1 hr. The reaction mixture was concentrated to dryness *in vacuo* and 100 mL each of diethyl ether and H_2O added. The aqueous layer acidified with 1N HCl until pH=2. Methylene chloride was added and the aqueous phase was extracted
30 with additional CH_2Cl_2 (2 X 100 mL). The combined extracts were dried (MgSO_4) and concentrated to dryness

in vacuo to give 0.390 g of white solid 4-amino-3-chloro-6-(3,5-dichlorophenoxy)pyridine-2-carboxylic acid (Compound 47); mp 196°C.

- 5 The following 6-phenoxy analogs of 4-amino-3-chloropyridine-2-carboxylic acid were prepared according to the procedure of Example 27:

10 4-amino-3-chloro-6-phenoxy-pyridine-2-carboxylic acid (Compound 48); mp 178°C.

15 4-amino-3-chloro-6-(4-methoxyphenoxy)-pyridine-2-carboxylic acid (Compound 49); mp 174°C.

 4-amino-3-chloro-6-(4-methylphenoxy)-pyridine-2-carboxylic acid (Compound 50); mp 173°C.

20 4-amino-3-chloro-6-(3,4-dichlorophenoxy)-pyridine-2-carboxylic acid (Compound 51); mp 186-187°C.

25 4-amino-3-chloro-6-(3-methylphenoxy)-pyridine-2-carboxylic acid (Compound 52); mp 169°C.

30 4-amino-3-chloro-6-(3-chlorophenoxy)-pyridine-2-carboxylic acid (Compound 53); mp 176°C.

28. Preparation of 4-Amino-3,5-dichloro-6-phenoxypyridine-2-carboxylic acid (Compound 54)

5 A. Preparation of Methyl 4-amino-3,5-dichloro-6-phenoxypyridine-2-carboxylate

A solution of 4-amino-3,5,6-trichloro-pyridine-2-carboxylic acid (7.2 g, 0.03 mol), phenol (3.0 g, 0.036 mol) and sodium hydroxide (2.7 g 0.068 mol) in DMSO (60 mL) and water (9 mL) was heated to 130°C for 18 hr. The reaction was diluted with water (250 mL) and a tacky solid collected. This material was dissolved in methanol (100 mL) and treated with TMSCHN₂ (25 mL 2M in hexanes). The reaction was stirred 30 min and concentrated. The resulting oil was chromatographed over silica gel (80% hexane and 20% ethyl acetate) to give methyl 4-amino-3,5-dichloro-6-phenoxypyridine-2-carboxylate (1.2, g, 14%); mp 88-90°C.

20

B. Preparation of 4-Amino-3,5-dichloro-6-phenoxypyridine-2-carboxylic acid (Compound 54)

To a solution of methyl 4-amino-3,5-dichloro-6-phenoxypyridine-2-carboxylate in methanol (10 mL) and water (100 mL) was added sodium hydroxide (0.5 g excess) and the solution heated under reflux for 3 hr. The solution was cooled and concentrated hydrochloric acid (2 mL) added. The solid was collected to give 4-amino-3,5-dichloro-6-

30

phenoxypyridine-2-carboxylic acid (1.1 g, 90%); mp 158-60°C.

29. Preparation of 4-Amino-3-chloro-5-fluoro-6-(3,4-dichlorophenoxy)pyridine-2-carboxylic acid (Compound 55)

4-Amino-3-chloro-6-(3,4-dichlorophenoxy)-pyridine-2-carboxylic acid was fluorinated with [1-(chloromethyl)-4-fluoro-1,4-diazoniabicyclo-[2.2.2]octane bis(tetrafluoroborate)] (F-TEDA) in refluxing acetonitrile; mp 156-160°C.

30. Preparation of 4-Amino-3,5-dichloro-6-(2-methylpropoxy)pyridine-2-carboxylic acid (Compound 56)

4-amino-3,5-dichloro-6-(2-methylpropoxy)-pyridine-2-carboxylic acid (Compound 56) was prepared following the procedure of Example 27 using 2-methylpropanol instead of phenol; mp 104-6°C.

31. Preparation of Herbicidal Compositions

In the following illustrative compositions, parts and percentages are by weight.

EMULSIFIABLE CONCENTRATES

Formulation A

	<u>WT%</u>
4-Amino-3,6-dichloropicolinate, 2-butoxyethyl ester	26.2
Polyglycol 26-3	5.2
Nonionic emulsifier-(di-sec- butyl)phenylpoly(oxypropylene)b lock polymer with oxyethylene). The polyoxyethelene content is about 12 moles.	
Witconate P12-20 (Anionic emulsifier-calcium dodecylbenzene sulfonate- 60 wt. % active)	5.2
Aromatic 100 (Xylene range aromatic solvent)	63.4

5

Formulation B

	<u>WT%</u>
4-Amino-3,6-dichloropicolinate, 2-ethylhexyl ester	3.5
Sunspray 11N (paraffin oil)	40.0
Polyglycol 26-3	19.0
Oleic acid	1.0
Xylene range aromatic solvent	36.5

Formulation C

	<u>WT%</u>
4-Amino-3,6-dichloropicolinate, n-butyl ester	13.2
Stepon C-65	25.7
Ethomeen T/25	7.7
Ethomeen T/15	18.0
Xylene range aromatic solvent	35.4

These concentrates can be diluted with water to give emulsions of suitable concentrations for controlling weeds.

5

WETTABLE POWDERS

Formulation D

	<u>WT%</u>
4-Amino-3,6-dichloropicolinic acid	26.0
Polyglycol 26-3	2.0
Polyfon H	4.0
Zeosyl 100 (Precipitated hydrated SiO ₂)	17.0
Barden clay + inerts	51.0

10

Formulation E

	<u>WT%</u>
4-Amino-3,6-dichloropicolinic acid	62.4
Polyfon H (sodium salt of lignin sulfonate)	6.0
Sellogen HR (sodium naphthalene sulfonate)	4.0
Zeosyl 100	27.6

5 The active ingredient is applied to the corresponding carriers and then these are mixed and ground to yield wettable powders of excellent wettability and suspension power. By diluting these wettable powders with water it is possible to obtain suspensions of suitable concentrations for controlling weeds.

10

WATER DISPERSIBLE GRANULES

Formulation F

	<u>WT%</u>
4-Amino-3,6-dichloropicolinic acid	26.0
Sellogen HR	4.0
Polyfon H	5.0
Zeosyl 100	17.0
Kaolinite clay	48.0

15

The active ingredient is added to the hydrated silica, which is then mixed with the other ingredients and ground to a powder. The powder is agglomerated with water and sieved to provide granules in the range of

-10 to +60 mesh. By dispersing these granules in water it is possible to obtain suspensions of suitable concentrations for controlling weeds.

5

GRANULES

Formulation G

	<u>WT%</u>
4-Amino-3,6-dichloropicolinic acid	5.0
Celetom MP-88	95.0

10 The active ingredient is applied in a polar solvent such as N-methyl-pyrrolidinone, cyclohexanone, gamma-butyrolactone, etc. to the Celetom MP 88 carrier or to other suitable carriers. The resulting granules can be applied by hand, granule applicator, airplane, etc. in order to control weeds.

15

Formulation H

	<u>WT%</u>
4-Amino-3,6-dichloropicolinic acid	1.0
Polyfon H	8.0
Nekal BA 77	2.0
Zinc Stearate	2.0
Barden Clay	87.0

20 All materials are blended and ground to a powder then water is added and the clay mixture is stirred until a paste is formed. The mixture is extruded through a die to provide granules of proper size.

Water Soluble Liquids

Formulation I

	<u>Wt%</u>
4-Amino-3,6-dichloropicolinic acid	11.2
KOH	3.7
Water	85.1

4-Amino-3,6-dichloropicolinic acid is dispersed in water. KOH is slowly added to neutralize the acid to a pH of between 9-12. A water-soluble surfactant may be added. Other aids may be incorporated to improve physical, chemical and/or formulation properties.

32. Evaluation of Postemergence Herbicidal Activity

Seeds of the desired test plant species were planted in Grace-Sierra MetroMix® 306 planting mixture, which typically has a pH of 6.0 to 6.8 and an organic matter content of about 30 percent, in plastic pots with a surface area of 64 square centimeters. When required to ensure good germination and healthy plants, a fungicide treatment and/or other chemical or physical treatment was applied. The plants were grown for 7-21 days in a greenhouse with an approximate 15 hr photoperiod which was maintained at about 23-29°C during the day and 22-28°C during the night. Nutrients and water were added on a regular basis and supplemental lighting was provided with overhead metal halide 1000-Watt lamps as necessary. The plants were

employed for testing when they reached the first or second true leaf stage.

A weighed amount, determined by the highest rate to be tested, of each test compound was placed in a 20 mL glass vial and was dissolved in 4 mL of a 97:3 v/v (volume/volume) mixture of acetone and dimethyl sulfoxide (DMSO) to obtain concentrated stock solutions. If the test compound did not dissolve readily, the mixture was warmed and/or sonicated. The concentrated stock solutions obtained were diluted with an aqueous mixture containing acetone, water, isopropyl alcohol, DMSO, Atplus 411F crop oil concentrate, and Triton X-155 surfactant in a 48.5:39:10:1.5:1.0:0.02 v/v ratio to obtain spray solutions of known concentration. The solutions containing the highest concentration to be tested were prepared by diluting 2 mL aliquots of the stock solution with 13 mL of the mixture and lower concentrations were prepared by serial dilution of the stock solution. Approximately 1.5 mL aliquots of each solution of known concentration were sprayed evenly onto each of the test plant pots using a DeVilbiss atomizer driven by compressed air pressure of 2 to 4 psi (140 to 280 kiloPascals) to obtain thorough coverage of each plant. Control plants were sprayed in the same manner with the aqueous mixture. In this test an application rate of 1 ppm results in the application of approximately 1 g/Ha.

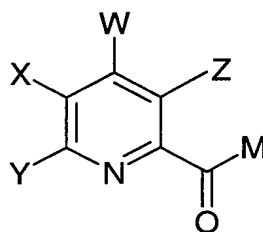
The treated plants and control plants were placed in a greenhouse as described above and watered by sub-irrigation to prevent wash-off of the test

compounds. After 2 weeks the condition of the test plants as compared with that of the untreated plants was determined visually and scored on a scale of 0 to 100 percent where 0 corresponds to no injury and 100 corresponds to complete kill.

By applying the well-accepted probit analysis as described by J. Berkson in *Journal of the American Statistical Society*, **48**, 565 (1953) and by D. Finney in "*Probit Analysis*" Cambridge University Press (1952), the above data can be used to calculate GR_{50} and GR_{80} values, which are defined as growth reduction factors that correspond to the effective dose of herbicide required to kill or control 50 percent or 80 percent, respectively, of a target plant.

Some of the compounds tested, application rates employed, plant species tested, and results are given in Tables 1-2. Selectivity to rice, corn and wheat are illustrated in Tables 3-5.

Table 1

Post-emergent % Control

#	M	W	X	Y	Z	% Control			Rate (ppm)
						XANST	STEME	POLCO	
1	OH	NH ₂	H	Cl	Cl	95	100	100	125
2	O-2-EH ²	NH ₂	H	Cl	Cl	95	80	100	250
3	O-Me	NH ₂	H	Cl	Cl	100	100	100	125
4	O-Et	NH ₂	H	Cl	Cl	100	100	100	125
5	O-Pr	NH ₂	H	Cl	Cl	100	100	100	125
6	O- <i>i</i> -Pr	NH ₂	H	Cl	Cl	100	100	100	125
7	O-Bu	NH ₂	H	Cl	Cl	100	100	100	250
8	O-pentyl	NH ₂	H	Cl	Cl	100	90	100	250
9	O-hexyl	NH ₂	H	Cl	Cl	100	100	100	250
10	O-BE ³	NH ₂	H	Cl	Cl	90	50	100	125
11	NH ₂	NH ₂	H	Cl	Cl	80	85	95	125
12	O-Me	NHC(O)Me	H	Cl	Cl	90	30	100	125
13	O-Me	N(C(O)Me) ₂	H	Cl	Cl	95	100	80	250
14	OH	NH ₂	H	Br	Cl	85	90	50	250
15	OH	NH ₂	H	F	Cl	100	70	90	250
16	OH	NH ₂	F	Br	F	60	30	70	250
17	OH	NH ₂	H	Br	Br	100	80	100	250
18	O-Me	NH ₂	Br	Br	Br	85	90	75	250
19	OH	NH ₂	F	Cl	Cl	95	95	100	125
20	OH	NH ₂	Br	Cl	Cl	85	90	50	250
21	OH	NH ₂	CF ₃	Cl	Cl	70	20	20	250

22	OH	NH ₂	O-Me	Cl	Cl	80	90	100	250
23	OH	NH ₂	S-Et	Cl	Cl	90	90	98	125
24	OH	NH ₂	S-Ph	Cl	Cl	60	50	50	250
25	O-Me	NH ₂	NO ₂	Cl	Cl	60	50	50	250
26	OH	NHMe	H	Cl	Cl	90	90	95	125
27	OH	NHEt	H	Cl	Cl	85	100	90	125
28	OH	NH- <i>i</i> -Pr	H	Cl	Cl	95	90	95	250
29	OH	NHBu	H	Cl	Cl	95	90	90	250
30	OH	NH(allyl)	H	Cl	Cl	100	80	100	250
31	OH	NH(CH ₂) ₂ OH	Cl	Cl	Cl	40	30	70	250
32	OH	NH(CH ₂) ₂ OMe	H	Cl	Cl	80	20	100	250
33	OH	NMe ₂	H	Cl	Cl	100	100	100	250
34	OH	NMe(OH)	H	Cl	Cl	100	70	100	125
35	OH	NMe(OMe)	H	Cl	Cl	90	60	100	125
36	OH	pyrrolidine	H	Cl	Cl	50	40	80	125
37	OH	pyrrole	H	Cl	Cl	90	70	90	125
38	O-Me	N ₃	H	Br	Cl	90	50	90	125
39 ¹	OH	NO ₂	H	Cl	Cl	85	30	90	125
40	OH	N=CH(NMe ₂)	H	Cl	Cl	100	90	100	250
41	OH	NH ₂	H	Br	O-Me	80	90	100	125
42	OH	NH ₂	Cl	Br	O-Me	85	90	90	250
43	OH	NH ₂	Cl	Cl	F	90	85	60	125
44	OH	NH ₂	H	Cl	Br	90	90	95	125
45	O-Me	NH ₂	Cl	CF ₃	Cl	90	0	80	250
46	O-Me	NH ₂	H	CF ₃	Cl	90	60	100	250
47	OH	NH ₂	H	O-3,5-DCPh ⁴	Cl	100	100	100	250
48	OH	NH ₂	H	O-Ph	Cl	100	60	100	250
49	OH	NH ₂	H	O-4-MeOPh ⁵	Cl	60	0	70	250
50	OH	NH ₂	H	O-4-MePh ⁶	Cl	60	0	70	250
51	OH	NH ₂	H	O-3,4-DCPh ⁷	Cl	100	70	100	250
52	OH	NH ₂	H	O-3-MePh ⁸	Cl	70	20	90	250
53	OH	NH ₂	H	O-3-CPh ⁹	Cl	100	100	100	250
54	OH	NH ₂	Cl	O-Ph	Cl	100	0	40	250

55	OH	NH ₂	F	O-3,4-DCPh ⁷	Cl	100	95	100	250
56	OH	NH ₂	Cl	O-2-MP ¹⁰	Cl	85	30	20	250

¹Compound 39 is the pyridine *N*-oxide

²O-2-EH = O-2-ethylhexyl

³O-BE = O-(CH₂)₂OBu

⁴O-3,5-DCPh = O-3,5-DichloroC₆H₃

5 ⁵O-4-MeOPh = O-4-MethoxyC₆H₄

⁶O-4-MePh = O-4-MethylC₆H₄

⁷O-3,4-DCPh = O-3,4-DichloroC₆H₃

⁸O-3-MePh = O-3-MethylC₆H₄

⁹O-3-CPh = O-3-ChloroC₆H₄

10 ¹⁰O-2-MP = O-2-Methylpropyl

NT = not tested

XANST = cocklebur (*Xanthium strumarium*)

STEME = chickweed (*Stellaria media*)

POLCO = wild buckwheat (*Polygonum convolvulus*)

TABLE 2
POSTMERGENCE HERBICIDAL ACTIVITY & CONTROL

Cpd. No.	Rate, ppm	STEME	XANST	CHEAL	AMARE	ABUTH	VIOTR	POLCO	ALOMY	ECHCG	DIGSA	SETFA	SORBI	AVEFA
1	125	90	100	100	95	70	80	100	50	45	60	75	50	50
4	125	70	100	100	100	70	70	100	40	50	70	75	40	40
14	125	65	100	95	90	85	75	100	50	65	65	65	60	40
19	125	60	95	95	60	50	50	100	20	10	30	20	10	20

STEME=chickweed (*Stellaria media*)
 CHEAL=lambquarters (*Chenopodium album*)
 ABUTH=velvetleaf (*Abutilon theophrasti*)
 POLCO=wild buckwheat (*Polygonum convolvulus*)
 ECHCG=barnyardgrass (*Echinochloa crus-galli*)
 SETFA=giant foxtail (*Setaria faberi*)
 AVEFA=wild oats (*Avena fatua*)
 XANST=cocklebur (*Xanthium strumarium*)
 AMARE=pigweed (*Amaranthus retroflexus*)
 VIOTR=viola (*Viola tricolor*)
 ALOMY=blackgrass (*Alopecurus myosuroides*)
 DIGSA=crabgrass (*Digitaria sanguinalis*)
 SORBI=Rox orange sorghum (*Sorghum bicolor*)

Table 3

Control of Several Key Weeds in Rice

post emergent evaluation - % control				
cmpd#	ORYZA	ECHCG	CYPES	Rate (ppm)
1	10	75	75	250
14	10	65	75	250
27	40	70	50	250

ORYZA = rice (*Oryza sativa*)

ECHCG = Barnyardgrass (*Echinochloa crus-galli*)

CYPES = yellow nutsedge (*Cyperus esculentus*)

Table 4

Control of Several Key Weeds in Corn

Post-emergent Evaluation - % control					
cmpd #	ZEAMX	ABUTH	AMARE	XANST	Rate (ppm)
15	0	40	75	90	250
20	10	70	90	85	250
33	20	80	50	100	125
43	0	70	90	85	250

ZEAMX = corn (*Zea mays*)

ABUTH = velvetleaf (*Abutilion
theophrasti*)

AMARE = pigweed (*Amaranthus retroflexus*)

XANST = cocklebur (*Xanthium strumarium*)

Table 5

Control of Several Key Weeds in Wheat

Post-emergent Evaluation - % control					
cmpd #	TRZAS	STEME	CHEAL	POLCO	Rate (ppm)
14	0	70	70	90	250
23	20	30	90	98	125
41	10	20	90	100	250
46	10	50	100	100	31

TRZAS = wheat (*Triticum aestivum*)
 STEME = chickweed (*Stellaria media*)
 CHEAL = lambsquarters (*Chenopodium album*)
 POLCO = wild buckwheat (*Polygonum convolvulus*)

33. Evaluation of Preemergence Herbicidal Activity

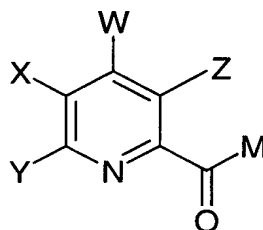
- 5 Seeds of the desired test plant species were planted in a soil matrix prepared by mixing a loam soil (43 percent silt, 19 percent clay, and 38 percent sand, with a pH of about 8.1 and an organic matter content of about 1.5 percent) and sand in a 70 to 30
- 10 ratio. The soil matrix was contained in plastic pots with a surface area of 113 square centimeters. When required to ensure good germination and healthy plants, a fungicide treatment and/or other chemical or physical treatment was applied.
- 15 A weighed amount, determined by the highest rate to be tested, of each test compound was placed in a 20 mL glass vial and was dissolved in 4 mL of a 97:3

v/v (volume/volume) mixture of acetone and dimethyl sulfoxide to obtain concentrated stock solutions. If the test compound did not dissolve readily, the mixture was warmed and/or sonicated. The stock solutions obtained were diluted with a 99.9:0.1 mixture of water and Tween® 155 surfactant to obtain application solutions of known concentration. The solutions containing the highest concentration to be tested were prepared by diluting 2 mL aliquots of the stock solution with 15 mL of the mixture and lower concentrations were prepared by serial dilution of the stock solution. A 2.5 mL aliquot of each solution of known concentration was sprayed evenly onto the soil surface (113 sq. cm) of each seeded pot using a Cornwall 5.0 mL glass syringe fitted with a TeeJet TN-3 hollow cone nozzle to obtain thorough coverage of the soil in each pot. Control pots were sprayed in the same manner with the aqueous mixture.

The treated pots and control pots were placed in a greenhouse maintained with an approximate 15 hr photoperiod and temperatures of about 23-29°C during the day and 22-28°C during the night. Nutrients and water were added on a regular basis and supplemental lighting was provided with overhead metal halide 1000-Watt lamps as necessary. The water was added by top-irrigation. After 3 weeks the condition of the test plants that germinated and grew as compared with that of the untreated plants that germinated and grew was determined visually and scored on a scale of 0 to 100 percent where 0 corresponds to no injury and 100 corresponds to complete kill or no

germination. Some of the compounds tested, application rates employed, plant species tested, and results are given in Tables 6-7.

Table 6

Pre-emergent % Control

#	M	W	X	Y	Z	IPOHE	% Control		Rate (ppm)
							AMARE	ABUTH	
1	OH	NH ₂	H	Cl	Cl	100	100	100	280
2	O-2-EH ²	NH ₂	H	Cl	Cl	100	100	100	280
3	O-Me	NH ₂	H	Cl	Cl	100	100	100	280
4	O-Et	NH ₂	H	Cl	Cl	100	100	100	280
5	O-Pr	NH ₂	H	Cl	Cl	100	100	100	280
6	O- <i>i</i> -Pr	NH ₂	H	Cl	Cl	100	100	100	280
7	O-Bu	NH ₂	H	Cl	Cl	100	100	100	280
8	O-pentyl	NH ₂	H	Cl	Cl	100	100	100	280
9	O-hexyl	NH ₂	H	Cl	Cl	100	98	100	280
10	O-BE ³	NH ₂	H	Cl	Cl	100	100	100	280
11	NH ₂	NH ₂	H	Cl	Cl	85	0	85	560
12	O-Me	NHC(O)Me	H	Cl	Cl	100	100	95	560
13	O-Me	N(C(O)Me) ₂	H	Cl	Cl	95	100	95	560
14	OH	NH ₂	H	Br	Cl	100	90	100	560
15	OH	NH ₂	H	F	Cl	100	100	100	560
16	OH	NH ₂	F	Br	F	80	70	0	560
17	OH	NH ₂	H	Br	Br	100	100	100	560
18	O-Me	NH ₂	Br	Br	Br	30	80	98	280
19	OH	NH ₂	F	Cl	Cl	100	100	100	560
20	OH	NH ₂	Br	Cl	Cl	100	100	100	560
21	OH	NH ₂	CF ₃	Cl	Cl	90	80	80	560

22	OH	NH ₂	O-Me	Cl	Cl	100	100	100	560
23	OH	NH ₂	S-Et	Cl	Cl	0	40	40	560
24	OH	NH ₂	S-Ph	Cl	Cl	30	20	50	560
25	O-Me	NH ₂	NO ₂	Cl	Cl	nt	nt	nt	250
26	OH	NHMe	H	Cl	Cl	100	100	100	560
27	OH	NHEt	H	Cl	Cl	100	100	100	560
28	OH	NH- <i>i</i> -Pr	H	Cl	Cl	100	100	100	560
29	OH	NHBu	H	Cl	Cl	100	100	100	560
30	OH	NH(allyl)	H	Cl	Cl	85	90	95	560
31	OH	NH(CH ₂) ₂ OH	Cl	Cl	Cl	100	95	95	560
32	OH	NH(CH ₂) ₂ OMe	H	Cl	Cl	90	70	90	560
33	OH	NMe ₂	H	Cl	Cl	100	100	98	560
34	OH	NMe(OH)	H	Cl	Cl	95	100	100	560
35	OH	NMe(OMe)	H	Cl	Cl	85	95	90	560
36	OH	pyrrolidine	H	Cl	Cl	80	80	95	560
37	OH	pyrrole	H	Cl	Cl	95	100	100	560
38	O-Me	N ₃	H	Br	Cl	100	100	100	560
39 ¹	OH	NO ₂	H	Cl	Cl	100	100	100	560
40	OH	N=CH(NMe ₂)	H	Cl	Cl	100	100	100	560
41	OH	NH ₂	H	Br	O-Me	85	40	90	280
42	OH	NH ₂	Cl	Br	O-Me	100	100	100	560
43	OH	NH ₂	Cl	Cl	F	70	30	80	140
44	OH	NH ₂	H	Cl	Br	100	100	100	560
45	O-Me	NH ₂	Cl	CF ₃	Cl	100	100	90	125
46	O-Me	NH ₂	H	CF ₃	Cl	100	95	95	140
47	OH	NH ₂	H	O-3,5-DCPh ⁴	Cl	0	100	95	280
48	OH	NH ₂	H	O-Ph	Cl	100	30	100	280
49	OH	NH ₂	H	O-4-MeOPh ⁵	Cl	0	0	0	70
50	OH	NH ₂	H	O-4-MePh ⁶	Cl	0	0	0	70
51	OH	NH ₂	H	O-3,4-DCPh ⁷	Cl	0	98	80	280
52	OH	NH ₂	H	O-3-MePh ⁸	Cl	70	20	50	560
53	OH	NH ₂	H	O-3-CPh ⁹	Cl	100	0	100	560

54	OH	NH ₂	Cl	O-Ph	Cl	41	10	50	280
55	OH	NH ₂	F	O-3,4-DCPh ⁷	Cl	100	95	100	250
56	OH	NH ₂	Cl	O-2-MP ¹⁰	Cl	0	0	40	560

¹Compound 39 is the pyridine *N*-oxide

²O-2-EH = O-2-ethylhexyl

³O-BE = O-(CH₂)₂OBu

⁴O-3,5-DCPh = O-3,5-DichloroC₆H₃

5 ⁵O-4-MeOPh = O-4-MethoxyC₆H₄

⁶O-4-MePh = O-4-MethylC₆H₄

⁷O-3,4-DCPh = O-3,4-DichloroC₆H₃

⁸O-3-MePh = O-3-MethylC₆H₄

⁹O-3-CPh = O-3-ChloroC₆H₄

10 ¹⁰O-2-MP = O-2-Methylpropyl

NT = not tested

IPOHE = morningglory (*Ipomoea hederacea*)

AMARE = pigweed (*Amaranthus retroflexus*)

ABUTH = velvetleaf (*Abutilon theophrasti*)

TABLE 7
PREEMERGENCE HERBICIDAL ACTIVITY & CONTROL

Cpd. No.	Rate, g/Ha	XANST	CHEAL	AMARE	ABUTH	EPHHL	ALOMY	ECHCG	DIGSA	SETFA	SORBI	AVEFA
1	35	99	99	88	95	62	36	17	20	40	60	37
3	35	90	100	90	95	20	nt	20	40	40	30	10
14	35	100	100	100	100	70	60	40	80	98	50	40
42	35	98	90	60	80	40	30	30	30	30	20	30

nt=no test

CHEAL=lambsquaters (*Chenopodium album*)

XANST=cocklebur (*Xanthium strumarium*)

AMARE=pigweed (*Amaranthus retroflexus*)

ABUTH=velvetleaf (*Abutilon theophrasti*)

EPHHL=wild poinsettia (*Euphorbia heterophylla*)

ALOMY=blackgrass (*Alopecurus myosuroides*)

ECHCG=barnyardgrass (*Echinochloa crus-galli*)

DIGSA=crabgrass (*Digitaria sanguinalis*)

SETFA=giant foxtail (*Setaria faberi*)

SORBI=Rox orange sorghum (*Sorghum bicolor*)

AVEFA=wild oats (*Avena fatua*)

34. Range & Pasture Crop Testing

Rates are calculated based upon 5 doses being applied. The high rate (X), followed by serial dilutions of 1/2X, 1/4X, 1/8X and 1/16X. Compound requirements are based upon the 187 L/ha carrier volume, specifications of the delivery system (Mandel track sprayer) and generating 24 mL of technical spray material to allow for the dilutions and overage in the sprayer.

10

$$\frac{\text{Rate g/ha}}{187 \text{ L/ha}} = \frac{\text{X mg}}{24 \text{ mL}}$$

Example:	<u>Starting X rate (g/ha)</u>	<u>mgs required</u>
15	560	71.9
	280	35.9
	140	17.95
	70	8.9

20 All technical materials were formulated in 97:3 (acetone:DMSO) with 0.25% X-77. The total volume of solvent is maintained at less than 7%. An overhead Mandel track sprayer calibrated to deliver 187 L/ha was used for all treatment applications (post-
25 emergence). Picloram was included as a comparison treatment.

Solutions were applied with a mechanized track-sprayer at the following settings:

Nozzle: 8002E

30 Speed: 2 mph (3.2 km/hr)

Spray Pressure: 40 psi (276 kPa)

Spray height: 17 inches (43 cm) above top of plants

This provides an application volume of 187 L/ha

Percent weed control (burn down) was
 5 evaluated 3 weeks after treatment. Visual control on
 a 0-100 linear scale was used, with 0 representing no
 control and 100 representing total control. Burn down
 ratings were taken for annual and perennial weed
 species. Some of the compounds tested, application
 10 rates employed, plant species tested, and results are
 given in Tables 8-10.

Table 8

Salts of Compound 1

<u>salt</u>	Post-emergent GR ₈₀ g/Ha		
	CASOB	CONAR	CIRAR
free acid	11	59	47
potassium salt	<8.8	36	27
amine salt	<8.8	34	37
dimethylamine salt	11.8	>140	43
monoethanolamine salt	11	20	18
triethylamine salt	<8.8	16	<8.8
triisopropanolam ine salt	11	20	43

15 CASOB=sicklepod (*Cassia obtusifolia*)
 CONAR=field bindweed (*Convolvulus arvensis*)
 CIRAR=Canada thistle (*Cirsium arvense*),
 3 week evaluation

Table 9

Control of Several Key Weeds in Pasture

Post-emergent Evaluation - % control

Cmpd #	AGRCR	CIRAR	RUMOB	AMBEL	Rate (g/Ha)
3	30	90	100	100	70
6	30	95	100	93	70
26	10	90	100	nt	70
23	30	80	100	85	70

AGRCR = crested wheatgrass (*Agropyron cristatum*) (grass crop)
 CIRAR = Canada thistle (*Cirsium arvense*)
 RUMOB = broadleaf dock (*Rumex obtusifolia*)
 AMBEL = common ragweed (*Ambrosia artemisiifolia*)
 3 week evaluation
 nt = not tested

Table 10

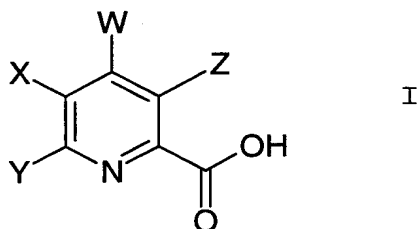
**Control of Several Key Weeds in
Clover Pasture**

Cmpd	g/ha		
	GR₂₀	GR₈₀	GR₈₀
	TRFRE	CONAR	CIRAR
3	<17.5	127.7	<17.5
4	<17.5	59	<17.5
5	<17.5	140.1	<17.5
6	98.8	98.8	<17.5
7	15.3	116.6	17.3
9	20.7	66	20.7

TRFRE=White Clover (*Trifolium repens*)
 CONAR=Field Bindweed (*Convolvulus arvensis*)
 CIRAR=Canada thistle (*Cirsium arvense*)

WHAT IS CLAIMED IS:

1. A compound of Formula I:



wherein

- 5 X represents H, halogen, C₁-C₆ alkoxy, C₁-C₆ alkylthio, aryloxy, nitro, or trifluoromethyl;

Y represents halogen, C₁-C₆ alkoxy, C₁-C₆ alkylthio, aryloxy, heteroaryloxy or trifluoromethyl;

- 10 Z represents halogen, C₁-C₆ alkoxy, C₁-C₆ alkylthio, aryloxy or nitro; and

W represents -NO₂, -N₃, -NR₁R₂, -N=CR₃R₄ or -NHN=CR₃R₄

where

- 15 R₁ and R₂ independently represent H, C₁-C₆ alkyl, C₃-C₆ alkenyl, C₃-C₆ alkynyl, aryl, heteroaryl, hydroxy, C₁-C₆ alkoxy, amino, C₁-C₆ acyl, C₁-C₆ carboalkoxy, C₁-C₆ alkylcarbonyl, C₁-C₆ alkylsulfonyl, C₁-C₆ trialkylsilyl or C₁-C₆ dialkyl phosphonyl or R₁ and R₂ taken together with N represent a 5- or 6-
20 membered saturated or unsaturated ring which may contain additional O, S or N heteroatoms; and

R₃ and R₄ independently represent H, C₁-C₆ alkyl, C₃-C₆ alkenyl, C₃-C₆ alkynyl, aryl or heteroaryl or R₃ and R₄ taken together with =C represent a 5- or 6-membered saturated ring; and

- 5 agriculturally acceptable derivatives of the carboxylic acid, with the proviso that when X represents H or Cl, then Y and Z are not both Cl.

2. A compound of claim 1 wherein:

X represents H, halogen, or trifluoromethyl;

- 10 Y represents halogen, aryloxy, heteroaryloxy, or trifluoromethyl;

Z represents halogen; and

W represents -NR₁R₂

where

- 15 R₁ and R₂ independently represent H, C₁-C₆ alkyl, C₃-C₆ alkenyl, C₃-C₆ alkynyl or R₁ and R₂ taken together with N represent a 5- or 6-membered saturated ring which may contain additional O or N heteroatoms; and

- 20 agriculturally acceptable salts, esters or amides of the carboxylic acid.

3. A compound of claim 1 or claim 2

wherein:

X represents H or F;

Y represents F, Cl, Br or aryloxy;

Z represents Cl; and

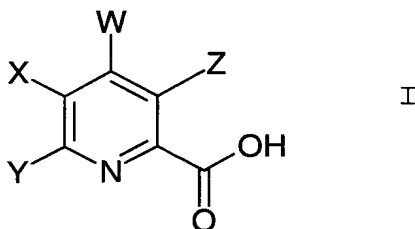
W represents -NH_2 .

5 4. A compound of any one of claims 1-3

wherein:

Y represents a phenoxy group substituted with halogen or $\text{C}_1\text{-C}_4$ alkyl groups in the 3-position.

10 5. An herbicidal composition comprising an herbicidally effective amount of a 4-aminopicolinate of Formula I:



15 wherein

X represents H, halogen, $\text{C}_1\text{-C}_6$ alkoxy, $\text{C}_1\text{-C}_6$ alkylthio, aryloxy, nitro or trifluoromethyl;

Y represents halogen, $\text{C}_1\text{-C}_6$ alkoxy, $\text{C}_1\text{-C}_6$ alkylthio, aryloxy, heteroaryloxy or trifluoromethyl;

Z represents halogen, C₁-C₆ alkoxy, C₁-C₆ alkylthio, aryloxy or nitro; and

W represents -NO₂, -N₃, -NR₁R₂, -N=CR₃R₄ or -NHN=CR₃R₄

5 where

R₁ and R₂ independently represent H, C₁-C₆ alkyl, C₃-C₆ alkenyl, C₃-C₆ alkynyl, aryl, heteroaryl, hydroxy, C₁-C₆ alkoxy, amino, C₁-C₆ acyl, C₁-C₆ carboalkoxy, C₁-C₆ alkylcarbonyl, C₁-C₆ alkylsulfonyl, 10 C₁-C₆ trialkylsilyl or C₁-C₆ dialkyl phosphonyl or R₁ and R₂ taken together with N represent a 5- or 6-membered saturated or unsaturated ring which may contain additional O, S or N heteroatoms; and

R₃ and R₄ independently represent H, C₁-C₆ 15 alkyl, C₃-C₆ alkenyl, C₃-C₆ alkynyl, aryl or heteroaryl or R₃ and R₄ taken together with =C represent a 5- or 6-membered saturated ring; and

agriculturally acceptable derivatives of the carboxylic acid, with the proviso that when X 20 represents Cl, then Y and Z are not both Cl, in admixture with an agriculturally acceptable adjuvant or carrier.

6. An herbicidal composition of claim 5 wherein:

25 X represents H, halogen or trifluoromethyl;

Y represents halogen, aryloxy, heteroaryloxy or trifluoromethyl;

Z represents halogen; and

W represents $-NR_1R_2$

where

R₁ and R₂ independently represent H, C₁-C₆
5 alkyl, C₃-C₆ alkenyl, C₃-C₆ alkynyl or R₁ and R₂ taken
together with N represent a 5- or 6-membered saturated
ring which may contain additional O or N heteroatoms;
and

agriculturally acceptable salts, esters or amides of
10 the carboxylic acid.

7. An herbicidal composition of claim 5 or
claim 6

wherein:

X represents H or F;

15 Y represents F, Cl, Br or aryloxy;

Z represents Cl; and

W represents $-NH_2$.

8. An herbicidal composition of any one of
claims 5-7

20 wherein:

Y represents a phenoxy group substituted
with halogen or C₁-C₄ alkyl groups in the 3-position.

9. An herbicidal composition of claim 5 containing 4-amino-3,6-dichloropyridine-2-carboxylic acid or an agriculturally acceptable salt, ester or amide thereof.

5 10. A method of controlling undesirable vegetation which comprises contacting the vegetation or the locus thereof with or applying to the soil to prevent the emergence of vegetation an herbicidally effective amount of an herbicidal composition of any
10 one of claims 5-9.

AMENDED CLAIMS

[received by the International Bureau on 15 May 2001 (15.05.01);
original claim 1 amended; remaining claims unchanged (1 page)]

R₃ and R₄ independently represent H, C₁-C₆ alkyl, C₃-C₆ alkenyl, C₃-C₆ alkynyl, aryl or heteroaryl or R₃ and R₄ taken together with =C represent a 5- or 6-membered saturated ring; and

- 5 agriculturally acceptable derivatives of the carboxylic acid, with the proviso that when X represents H or Cl, then Y and Z are not both Cl, or when X and Z both represent Cl, then Y is not Br.

2. A compound of claim 1 wherein:

- 10 X represents H, halogen, or trifluoromethyl;

Y represents halogen, aryloxy, heteroaryloxy, or trifluoromethyl;

Z represents halogen; and

W represents -NR₁R₂

- 15 where

R₁ and R₂ independently represent H, C₁-C₆ alkyl, C₃-C₆ alkenyl, C₃-C₆ alkynyl or R₁ and R₂ taken together with N represent a 5- or 6-membered saturated ring which may contain additional O or N heteroatoms;

- 20 and

agriculturally acceptable salts, esters or amides of the carboxylic acid.

3. A compound of claim 1 or claim 2

wherein:

- 25 X represents H or F;

INTERNATIONAL SEARCH REPORT

Intel. Patent Application No
PCT/US 01/01177

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C07D213/79 A01N43/40

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C07D A01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, CHEM ABS Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 755 338 A (GULBENK A) 28 August 1973 (1973-08-28) example 1 column 3, line 55 - line 60 column 4, line 3 - line 4 abstract	1,2
X	BE 788 756 A (DOW CHEMICAL CO) 13 March 1973 (1973-03-13) example 1 claims 4,5,8-10	1,5,6,8, 10

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
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- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *G* document member of the same patent family

Date of the actual completion of the international search

12 March 2001

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 01/01177

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	<p>US 3 285 925 A (DOW CHEMICAL CO) 15 November 1966 (1966-11-15) cited in the application column 1, line 30 - line 34 column 6, line 56 - line 57</p>	1,5,8,10
A	<p>GB 1 082 763 A (PROD CHIM IND ET AGRICOLES PRO) 13 September 1967 (1967-09-13) claim 1</p>	1,5,8-10
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A	<p>GB 1 363 415 A (ICI LTD) 14 August 1974 (1974-08-14) example 50 claim 20</p>	1,5,8-10
A	<p>US 3 325 272 A (DOW CHEM CO) 13 June 1967 (1967-06-13) cited in the application claim 1</p>	1,5,8-10

INTERNATIONAL SEARCH REPORT

information on patent family members

International Application No

PCT/US 01/01177

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